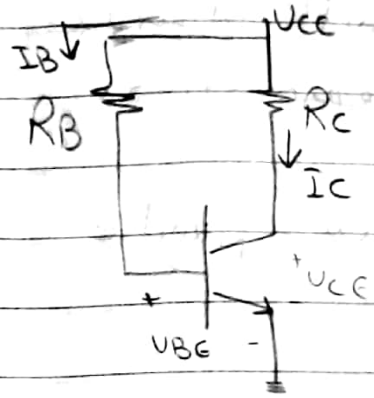
## Fixed_bias




$I_C = \beta I_B$

KVL DC

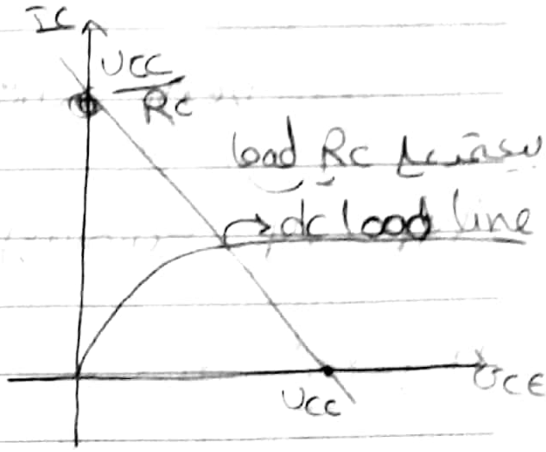
$V_{CC} = R_B I_B + V_{BE}$

$I_{BQ} = \frac{V_{CC} - V_{BE}}{R_B}$

$I_{CQ} = \beta I_B$

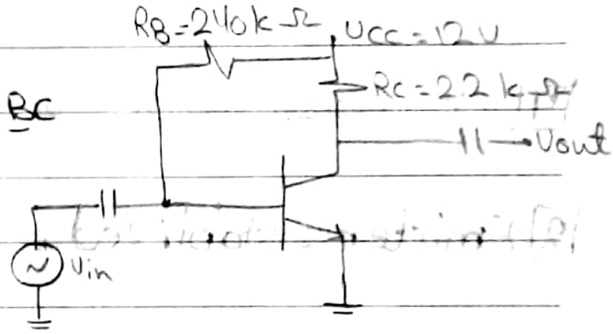
$V_{CEQ} = V_{CC} - I_{CQ} R_C$

Q Point

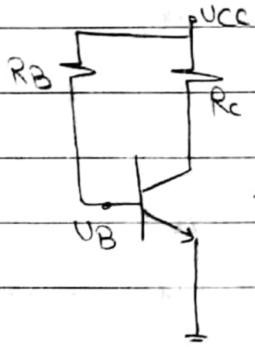



* مشتغل في ال active region بعيد عن cutoff
وعن saturation

EX 1:- find * $I_{BQ}$, $I_{CQ}$
* $V_{CEQ}$ * $V_B$, $V_C$ * $V_{BC}$




DC




$I_{BQ} = \frac{12 - 0.7}{240} = 47.08\,\mu A$

$I_{CQ} = \beta I_B = 50 \times 47.08 = 2.35\,mA$

$V_{CEQ} = V_{CC} - I_C R_C = 12 - (2.35)(2.2) = 6.83$

$V_B = V_{BE} = 0.7$

$V_C = V_{CE} = 6.83$

$V_{BC} = V_B - V_C = -6.13$

$I_{C\,sat}\Big|_{V_{CE}=0} = \frac{V_{CC}}{R_C} = 5.45\,mA$

← بتغيير الـ B يتم التأثير على $I_C$ وبالتالي هيأثر على $V_{CE}$ ومن الممكن الدخول على منطقة saturation.

← fixed حيث أنها تعتمد على B

very sensitive to temprature.

Type of Baising in BJT :-

[1] fixed Bais circuit.

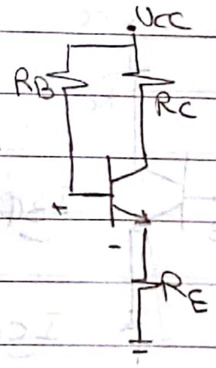
[2] Emitter - Stablized Bais circuit.

[3] voltage divider bias.

[4] Dc bias with voltage feedback.

[2] Emitter - Stablized. → more Stable.

الحصول على $I_C$ ثابت




$I_C = \beta I_B$ حيث التناسب عكسي بين $I_B$ و $\beta$ ← ①

$I_B = \alpha I_C$ وبالتالي $\beta \downarrow I_B \uparrow$ ← $I_C$ ثابت

$I_E = (\beta+1) I_B$

$V_{CC} = I_B R_B + V_{BE} + I_E R_E$

$$I_B = \frac{V_{CC} - V_{BE} - I_E R_E}{R_B}$$

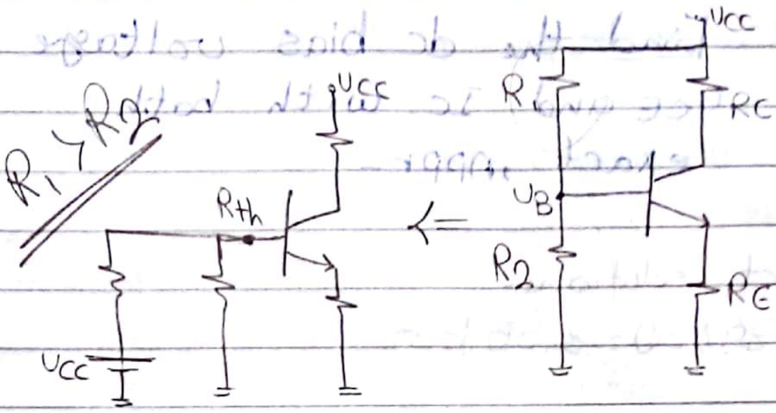
① ← $\uparrow I_B = \dfrac{V_{CC} - V_{BE}}{R_B + \downarrow(\beta+1) R_E}$

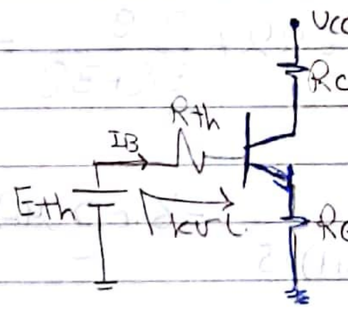
## [3] Voltage divider bias:- the best one

exact solution:-

$R_{th} = R_1 // R_2$

$E_{th} = U_{CC} * \frac{R_2}{R_1 + R_2}$




$I_E = (B+1) I_B$

$E_{th} - I_B R_{th} - U_{BE} - I_E R_E = 0$

$I_B = \frac{E_{th} - U_{BE}}{R_{th} + (B+1) R_E}$

$U_{CE} = U_{CC} - I_C (R_C + R_E)$ ✓

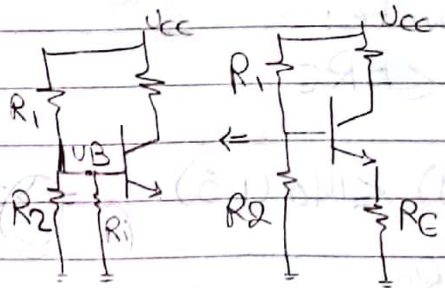
Approximate solution:-

$U_E = \underbrace{I_B (B+1)}_{I_E} R_E$

$R_i = \frac{U_E}{I_B} = (B+1) R_E$

$B \gg 1$

$\sim R_i = B \cdot R_E$



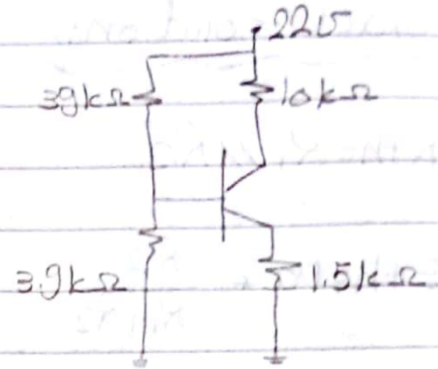

$\simeq U_B = \frac{R_2}{R_1 + R_2} U_{CC}$ $\Leftarrow$ $R_2 < \underbrace{R_i}_{\simeq \infty} \Rightarrow$ يهمل Ri في التوازي

$10 R_2 < B R_E$

Date Subject

EX4:-

Find the dc bias voltage $U_{CE}$ and $I_C$ with both exact, Appr-




$\beta = 140$

Repet $\boxed{\beta = 70}$

exact solution:-

$R_{th} = 39 // 3.9 = 3.55\ k\Omega$

$$E_{th} = U_{CC} * \frac{R_2}{R_2 + R_1} = 22 * \frac{3.9}{3.9 + 39} = 2$$

$$I_B = \frac{2 - 0.7}{3.55 + (\beta+1) 1.5} = 6.05\ \mu A$$

$I_C = \beta I_B = 140 * 6.05 = 0.85\ mA$

$U_{CE} = U_{CC} - I_C (R_C + R_E) = 12.22\ V$

Approximate:-

$10 R_2 \leq \beta R_E$

$10 (3.9) \leq 140 (1.5)$ $\Rightarrow$ satisfied.

$$U_B = \frac{R_2}{R_1 + R_2} U_{CC} = 2V$$

$U_E = U_B - U_{BE} = 2 - 0.7 = 1.3V$

$$I_{CQ} \simeq I_{EQ} = \frac{U_E}{R_E} = 0.867\ mA$$

$U_{CEQ} = U_{CC} - I_C (R_C + R_E) = 12.03\ V$

Scanned by CamScanner

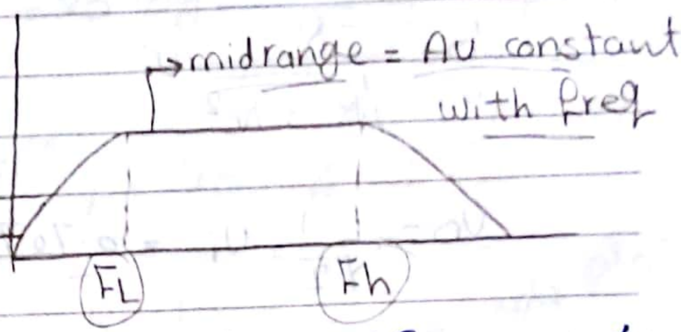
# Lec 2

Date Subject

## Frequancy Responce :-

تأثير التردد على شكل الدائرة والـ AV

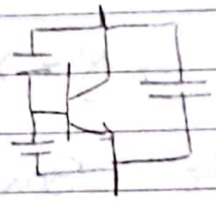
- Low freq
- high freq




$C_S, C_C, C_E$ هو اللي بيسبب الـ drop هو بيحصل roll off

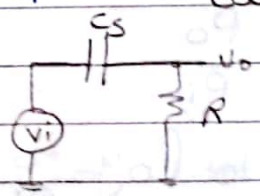
المكثفات الخارجية

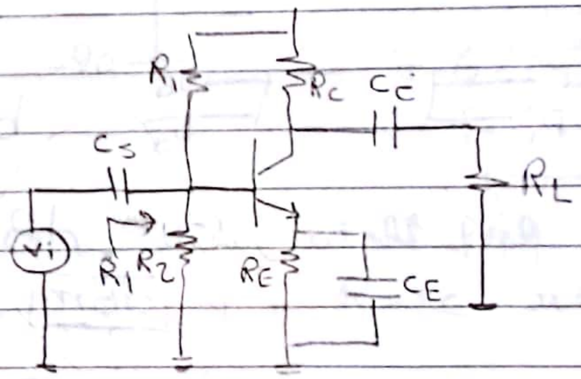
كما نوجد مكثفات داخليه تؤثر في high freq

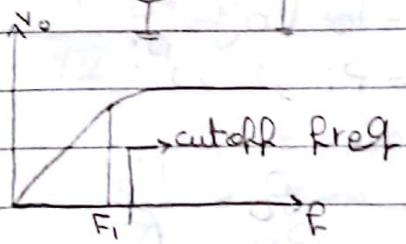


$$X_C = \frac{J}{2\pi f C}$$

دراسة كل دائرة على حدى




$X_C = \frac{J}{2\pi f C} = \infty$ $\quad \therefore f = 0$

$V_o = 0 \qquad A_V = \frac{V_o}{V_i} = 0$

$X_C = \frac{J}{2\pi f C} \simeq 0$ $\quad \therefore f \simeq \infty$

$\therefore V_o = V_i \qquad A_V = 1$

$V_o = V_i * \frac{R}{R - JX_C}$ | $A_V = \frac{R}{\sqrt{R^2 + X_C^2}} \tan^{-1}\left(\frac{X_C}{R}\right)$

Lec 2

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$F_c$ ← التردد الذي فيه تصبح $V_o = \frac{1}{\sqrt{2}} V_i$ أو يفضل عقد ! 3decimal

$$V_o = \frac{R}{\sqrt{R^2 + X_c^2}} V_i \qquad \therefore R = X_c$$

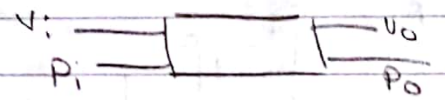
$$V_o = \frac{1}{\sqrt{2}} V_i = 0.707\, V_i \qquad \therefore V_o = 70\%\, V_i$$

cutoff Freq

$$P_{out} = \frac{1}{2} P_{in}$$

$$\text{At } F_1 \Rightarrow R = X_C \qquad = R = \frac{1}{2\pi F C} \qquad F_1 = \frac{1}{2\pi R C}$$

يفضل $C_c$ تكون كبيرة عشان أكبر Band width




$$\text{bel} = \log_{10} \frac{P_o}{P_i}$$

للتعبير $dB = \text{Decibel} = 10 \log \frac{P_o}{P_i}$

لو $1mW = P_i$ هنسميه ← $\boxed{dBm}$

$$A_P = 10 \log \frac{P_o}{P_i} \qquad P_o = \frac{V_o^2}{R}$$

للتعبير القيم ← $A_V = 20 \log \frac{V_o}{V_i}$ مهمة

$$\frac{V_o}{V_i} = \frac{R}{\sqrt{R^2 + X_c^2}} \tan^{-1} \frac{X_C}{R} = \frac{1}{\sqrt{1 + \left(\frac{X_C}{R}\right)^2}} \tan\left(\frac{X_C}{R}\right)$$

$$\frac{V_o}{V_i} = \frac{1}{\sqrt{1 + \left(\frac{F_1}{F}\right)^2}} \tan^{-1} \frac{F_1}{F}$$

Date Subject

at $f \ll f_1$ , $\left(\frac{f_1}{F}\right) \gg 1$

$$\frac{V_o}{V_i} = \frac{1}{\sqrt{1+\left(\frac{F_1}{F}\right)^2}} \quad \tan^{-1}\left(\frac{f_1}{f}\right) = 20\log\frac{1}{\sqrt{1+\left(\frac{F_1}{F}\right)^2}}$$

رفع لكسر $-\frac{1}{2}$

$$A_{V_{dB}} = -10\log\left(1+\left(\frac{F_1}{F}\right)^2\right) = -20\log\frac{F_1}{F}$$

At $F = F_1$

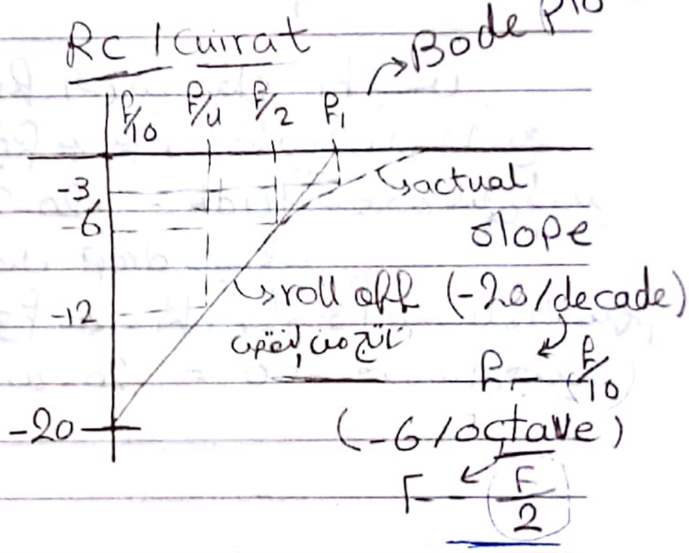
$\therefore \frac{F_1}{F} = 1$

$-20\log 2 = 0\,dB$

At $F = \frac{F_1}{2}$

$\therefore \frac{F_1}{F} = 2$

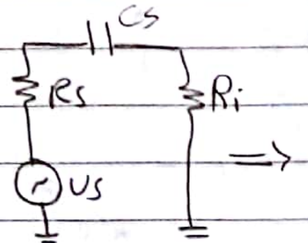
$-20\log 2 = -6\,dB$

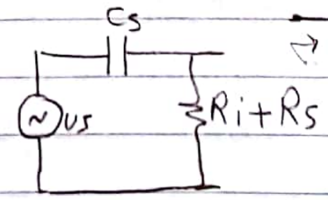


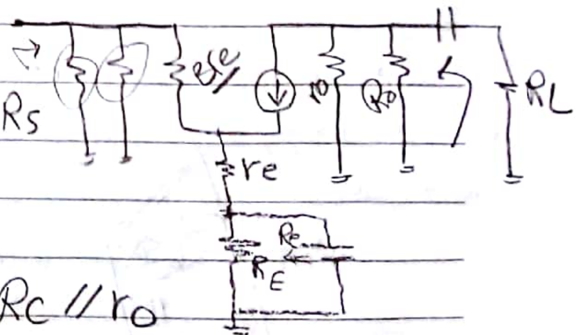

← cutoff freq : التردد الذي يحدث له drop عند $-3dB$ حيث $A_V = \frac{1}{\sqrt{2}}$

عند $R = X_C$ و $V_o = \frac{1}{\sqrt{2}}V_i$

$$A_V = -20\log\frac{1}{\sqrt{2}} = -3$$




$R_i = R_1 // R_2 // \beta r_e$

$R_o = R_C // r_o$

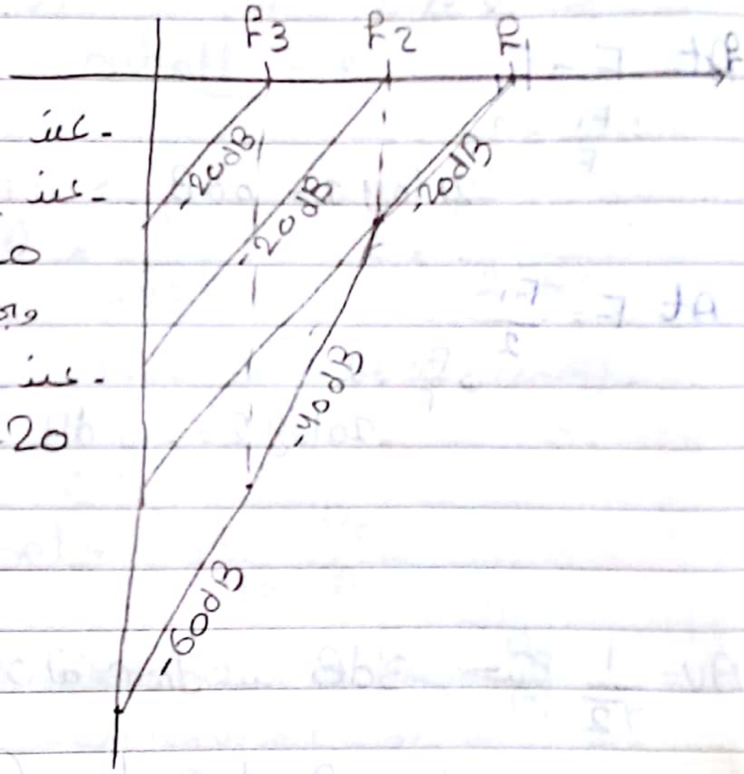
$$F_1 = \frac{1}{2\pi C(R_i + R_s)}$$

$$F_2 = \frac{1}{2\pi C(R_L // R_o)}$$

$$R_e = R_E // \left(r_e + \frac{R_1 // R_2 // R_3}{\beta}\right)$$

$$F_3 = \frac{1}{2\pi C R_e}$$

التردد الأعلى هو الذي يسبب drop أكبر
بيترسموا بنفس الميل -20db/decade




- عند $f_1$ الي بيشتغل $f_1$ بس
- عند $f_2 \Leftarrow f_1$ و $f_2$ بيشتغلوا الجمع
$-20-20 = -40dB$ وده ميل جديد
ويحصل drop بسرعة
- عند $f_3 \Leftarrow f_1, f_2$ و $f_3$ بيشتغلوا الجمع
$-20-20-20 = -60$ وده ميل جديد

$\boxed{R_1 = R_2}$

# Low Frequancy Response BJT and FET:

## Dc analysis

V.S → S.C

C.S → O.C ⇐ $V_{CE}$, $I_C$, $I_D$

—||— → O.C

—ooo— → S.C $X_C = \infty$

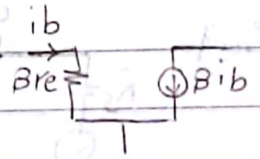
## Ac analysis

① V.S → S.C ② model BJT →

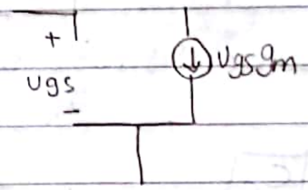
C.S → O.C

—||— → S.C

—ooo— → O.C

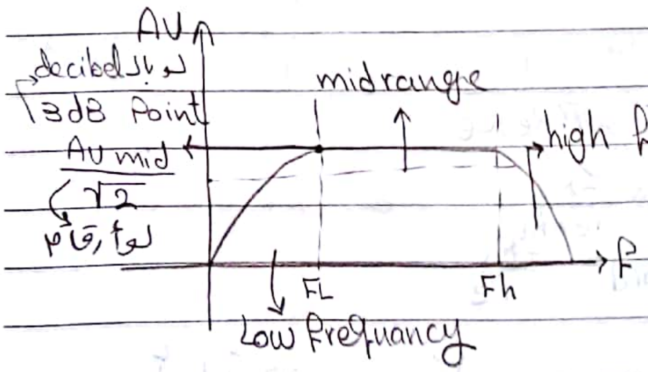


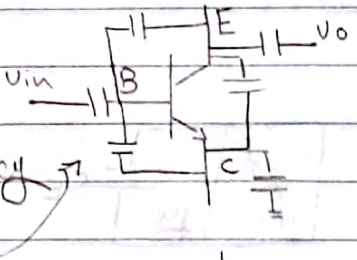

FET →




Rin, Rout, AV

## Frequency Response




$X_C = \frac{1}{2\pi f C}$ ⇐ تتغير F هيتغير Xc

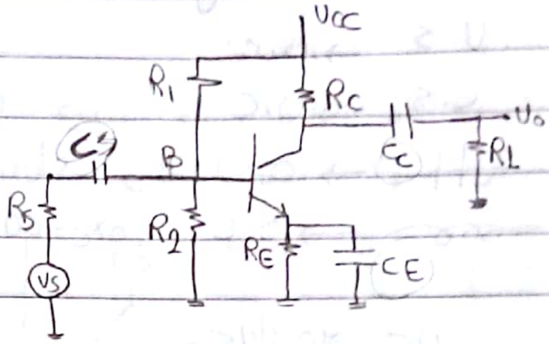
هيتغير AV

$AV = F(R_C, X_C)$

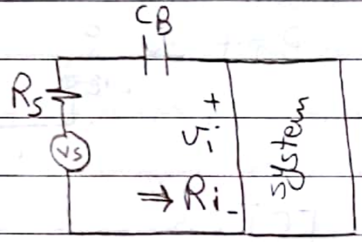
Rg

RG ← Stability ↓ Av ↓ ...

Low frequancy
[II] BJt




$\boxed{C_S}$

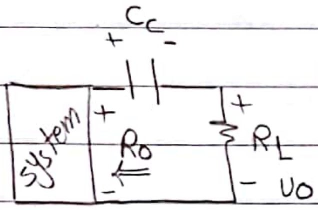



$$f_{LB} = \frac{1}{2\pi (R_S + R_i) C_B}$$

$$A_{V_{mid}} = V_o * \frac{R_i}{R_i + R_S}$$

CB → S.C

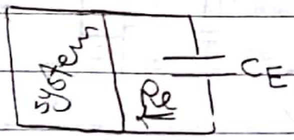
$\boxed{C_C}$




$$f_{LC} = \frac{1}{2\pi (R_L + R_o) C_C}$$

Ro → Ac Analysis

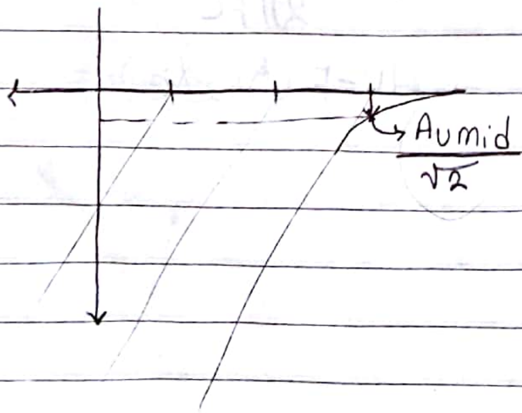
$\boxed{C_E}$




$$f_{LE} = \frac{1}{2\pi (R_e) C_E}$$

$$A_V = \frac{-R_C}{r_e \parallel R_E}$$

$$A_{V_{mid}} = \frac{-R_C}{r_e}$$



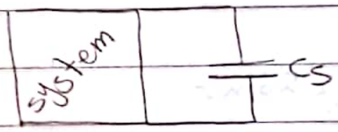

$F_L$ = أكبر تردد

## [2] FET

$$F_{LG} = \frac{1}{2\pi (R_{signal} + R_i)\, C_G}$$

$$F_{LD} = \frac{1}{2\pi (R_o + R_L)\, C_D}$$

$$F_{LS} = \frac{1}{2\pi\, R_{eq}\, C_s}$$




FET خطوات حل

[1] $g_{mo} = \frac{2 I_{DSS}}{V_P}$

$g_m = g_{mo}\left[1 - \frac{V_{GS\phi}}{V_P}\right]$

$I_{DSS} = I_S$ }
$V_{th} \to V_P$ } ثوابت

[2] $I_D = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2 \rightarrow ①$

[3] Q. Bdising بنطلع ② Q(طلع) $I_{D\phi}$, $V_{GS\phi}$

$R_{eq} =$ $r_d \neq \infty$ $\quad \frac{R_s}{1 + R_s[1 + g_m r_d] / [r_d + (R_D \parallel R_L)]}$

$r_d = \infty$ $\quad R_s \parallel \frac{1}{g_m}$

manual solution

Date Subject

# 9.7

14 with early effect $r_o = 40\ k\Omega$

15 19

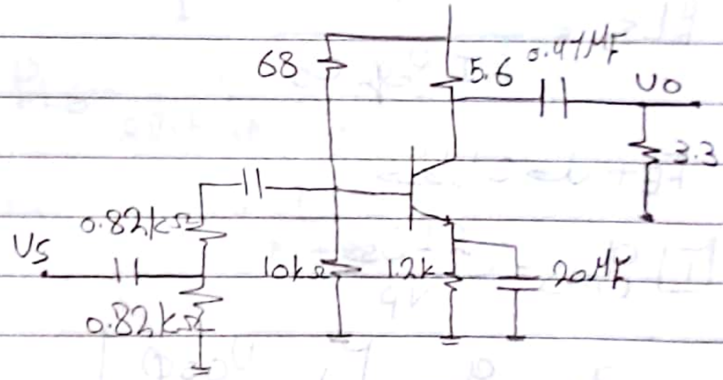
16 20

17 21 → report

18 22

23, 24, $\boxed{25}$ → repoRt

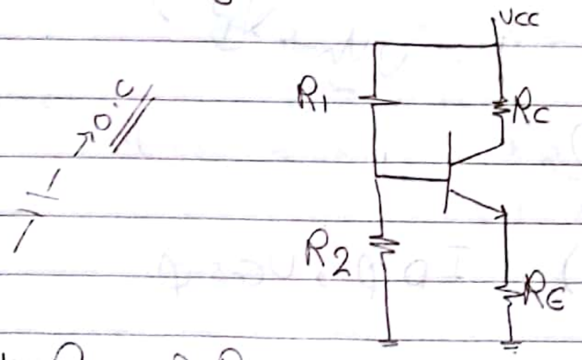
## $\boxed{15}$





$r_e = \frac{V_{th} \leftarrow 26mV}{I_E \leftarrow \text{Dc analysis}}$

I) Dc Analysis





$10R_2 \leq \beta R_E$

$10 * 10k\Omega \leq 120 * 1.2k\Omega$

$100k\Omega \leq 144k\Omega$

$V_B = V_{cc} * \frac{R_2}{R_1+R_2} = 14 * \frac{10k}{10k+68} = 1.794\ V$

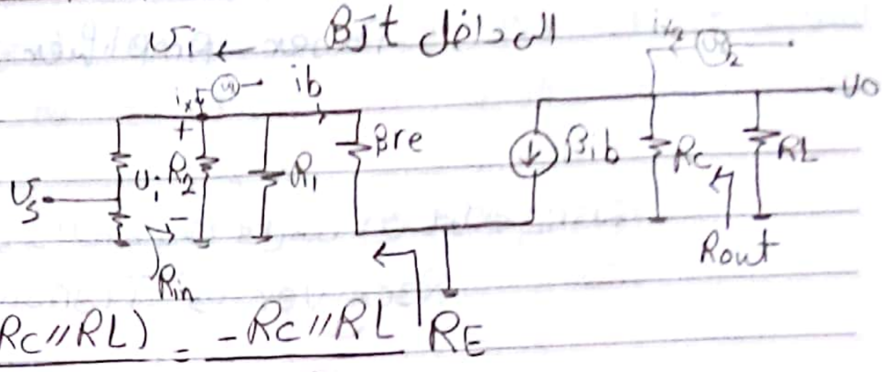
$V_{BE} = V_B - V_E \quad V_E = 1.79 - 0.7 = 1.095\ V$

$I_E = \frac{V_E}{R_E} = 0.913\ mA$ $\quad \therefore r_e = \frac{26mV}{0.913\ mA} = 28.46\Omega$

Date                Subject

# [2] Ac Analysis

الداخل BJt ← $v_i$



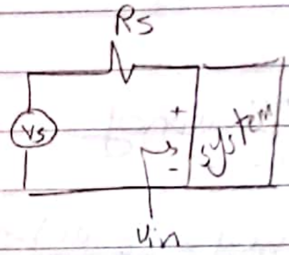

$$Av_{mid} = \frac{v_o}{v_i} = \frac{-\beta ib\,(R_C /\!/ R_L)}{\beta ib\, re} = \frac{-R_C /\!/ R_L}{re}$$

$$Z_i = \frac{v_x}{i_x} = R_1 /\!/ R_2 /\!/ \beta re$$

$$Z_{out} = \frac{v_{x_2}}{i_{x_2}} = R_C$$

$$Av_s = \frac{V_{out}}{V_s} = \frac{V_{out}}{v_i} * \frac{v_i}{v_s}$$

over all gain




$$v_i = V_s * \frac{Z_{in}}{R_s + Z_{in}}$$

$$\therefore Av_s = \frac{-R_C /\!/ R_L}{re} * \frac{Z_{in}}{R_s + Z_{in}}$$

$R_S$ ← المعوض بس

$$F_{LB} = \frac{1}{2\pi C_B (Z_i + R_s)} = 103.4$$

لما أجيب

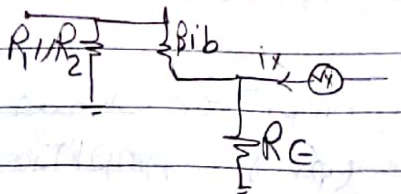
$$F_{LC} = \frac{1}{2\pi C_C (Z_o + R_C)} = 38.05$$

⇐ هناكتب لعوض B ينزل

مع عوض لتحت x B يطلع

$$F_{LE} = \frac{1}{2\pi C_E (R_e)} = 749.51$$

⇐ هرجع $R_E$ ، لأن معنا هنا حساب Re




$$R_E = \frac{v_x}{i_x} = R_E /\!/ \frac{\beta re + R_1 /\!/ R_2}{\beta}$$

$$F_L = F_{LE} = 749.51$$

# Power Amplifier

└ large signal → power

- بنكبر الإشارة بسبب وجود المفقد كل من الأسلاك والطاقة
- الناتجة من Receiver و Transimetter

Voltage Amplifier → هيجي الصوت (DC) → Power Amplifier

هنصنف ال Amplifier على أساس :-

## 1- efficiency

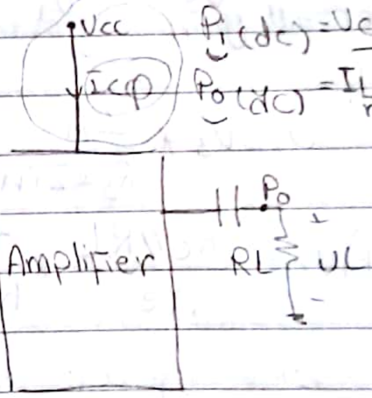
$$\text{Efficiency} = \frac{P_{o(dc)}}{P_{i(dc)}} \%$$

$P_{o(dc)} = I_{L\,rms}^2 R_L$

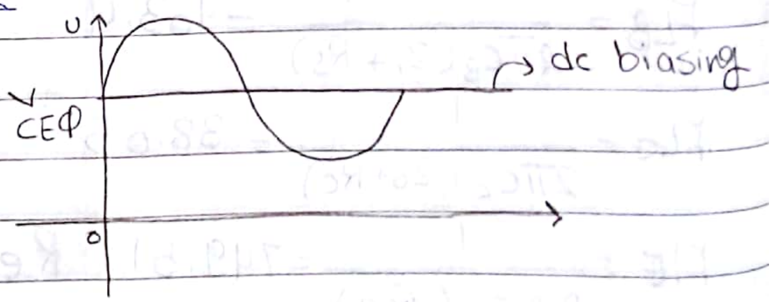
$P_{o(dc)} = \frac{V_{L\,rms}^2}{R_L}$

$P_{i(dc)} = V_{cc} I_{cq}$

$P_{o(dc)} = I_{L\,rms} V_{L\,rms}$




In practise $\neq 100\%$
because of
1- heat dissipation in the transistor
2- matching of inpedance between Load and output of amplifier



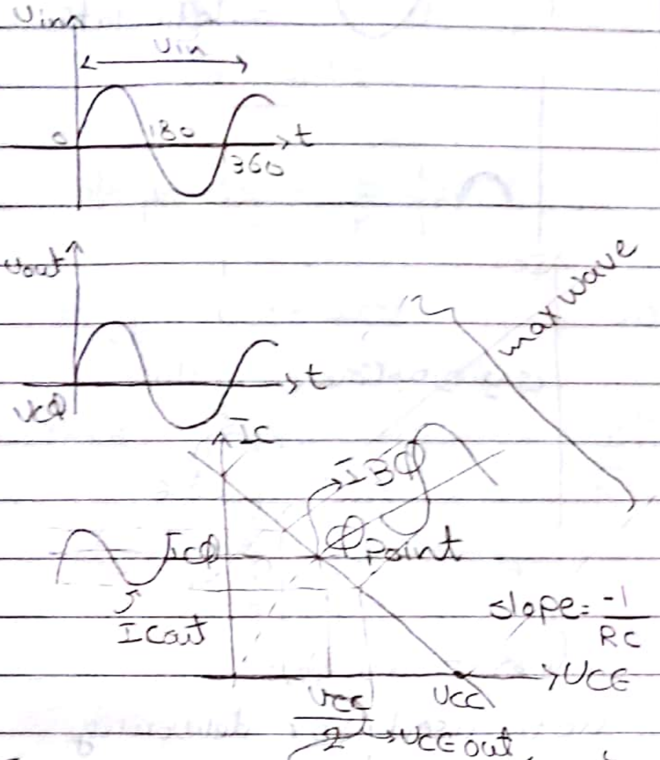

buffer , in/p high , ou/p Low , gain = 1

← هنصنف ال Amplifier على أساس فترة وجود التيار أي ان يكون Amplifier (on)

Date Subject

Amplifier classes represent the amount of the output signal varies over one cycle of operation for a full cycle of input

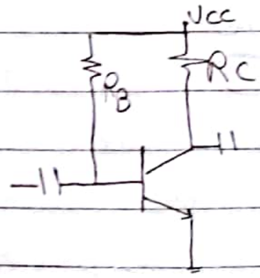
## class A




أقل كفاءة، وذلك بسبب وجود مصدر التيار، وبذلك الريش فقدان الخرج

$$\boxed{I_C} = \frac{V_{CC} - V_{CE}}{R_C}$$

$$\boxed{I_B} = \frac{V_{CC} - 0.7}{R_B}$$

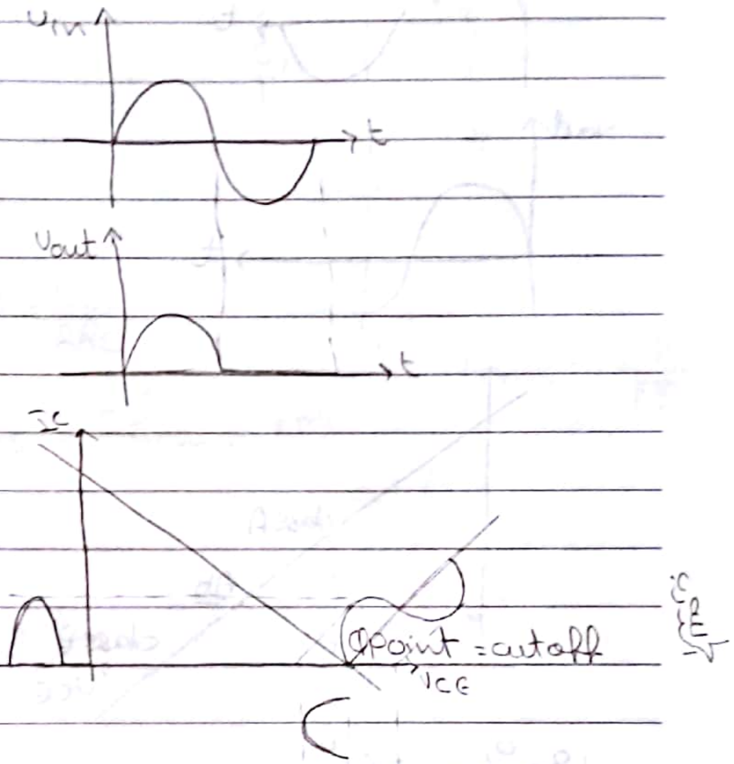



وعلى Q point هتكون عند $\frac{V_{CC}}{2}$ هيكون لها ميزه وهي max wave من Vcc إلى Ic

360° ← operating cycle

25% to 50% ← efficiency

## class B (push pull)




هتزود الكفاءة ولكن ليس بالكفاءة المطلوبة

حيث التيار الموجود في الفترة فقط

180°

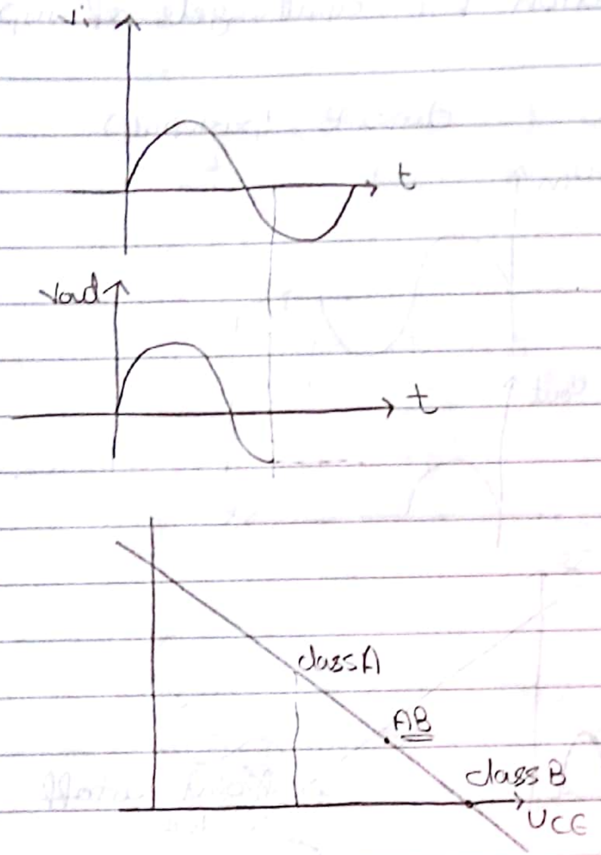
78%

4Writ

class A → classe B → classAB → classC

efficiency تزداد ال

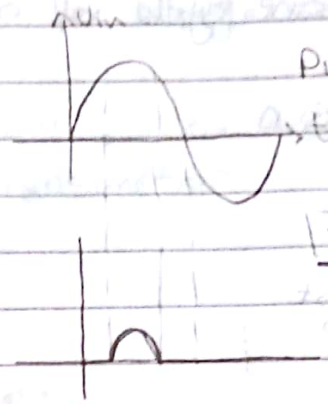
## class AB




180° to 360°

from 50% to 78.5

## class C

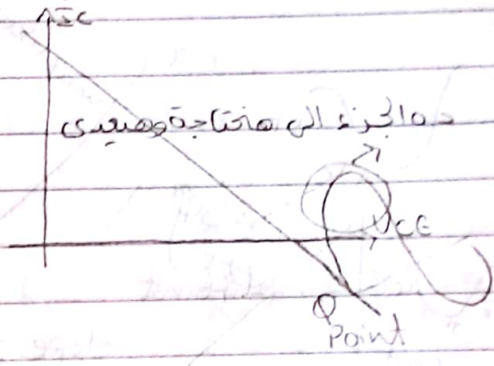



Puls

تستخدم في

logic gate

(PWS)




less than 180°

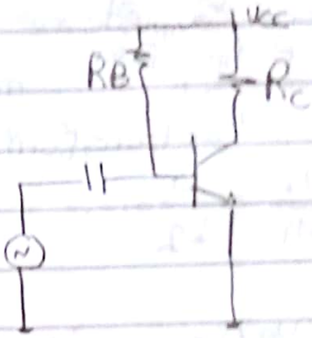
not used for delivering large amount of power thus the efficiency isn't given

3L

Date Subject

# class A

$$I_B = \frac{V_{CC} - 0.7}{R_B}$$




$I_C = \beta I_B$

$V_{CE} = V_{CC} - I_C R_C$

$$\text{efficiency} = \frac{P_{o(dc)}}{P_{i(dc)}}$$

$P_{i(dc)} = V_{CC} I_{C\phi}$ $\qquad I_{CQ} = \frac{V_{CC}}{2R_C}$

$V_{rms} = \frac{V_p}{\sqrt{2}}$

$$P_{o(dc)} = V_{CE_{rms}} I_{C_{rms}} = \frac{V_{CE_{rms}}^2}{R_C} = I_{C_{rms}}^2 * R_C$$

$P_i = \frac{V_{CC}^2}{2R_C}$

→ maximum efficiency

$V_p\,top = V_{CC}$

$I_p\,top = \frac{V_{CC}}{R_C}$ } max swing

$$\frac{V_{CC}}{2\sqrt{2}} \cdot \frac{V_{CC}}{2\sqrt{2} \cdot R_C} = \frac{V_{CC}^2}{8R_C} \quad P_{o(dc)}$$

بشيل مركب ال Ic

dc فقط

efficiency = 25%

EX:- $V_{CC} = 20V$ $R_C = 20\Omega$ $R_B = 1k\Omega$ $\beta = 25$

Base current 10 mA peak

$P_{i(dc)}, P_{o(dc)}, \eta$

$I_{B\phi} = \frac{20-0.7}{1} = 19.3$ mA

$I_{C\phi} = \beta I_B = 25(19.3) \simeq 0.48$ A

$V_{CE\phi} = V_{CC} - I_C R_C = 10.4$ V

$I_{Cp} = \underset{\beta}{25} * \underset{I_B}{10} = 0.25$ (peak)

$P_o = \frac{I_{Cp}^2}{2} R_C = 0.625$ W

$P_i = (V_{CC})(I_{C\phi}) = 9.6$

$20 * (I_{C\phi})$ ✓

$\eta = 6.5\%$

4 Writ

Date Subject

# class ~~B~~A

Transform coupled class A Amplifier.

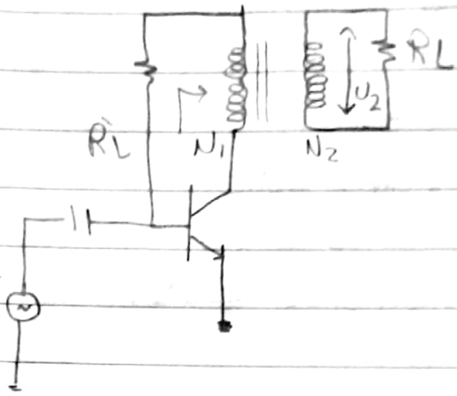
تشغيل class A

مشكلة RC وحط Transformer مكانها

matching لعمل

transformer

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}$$

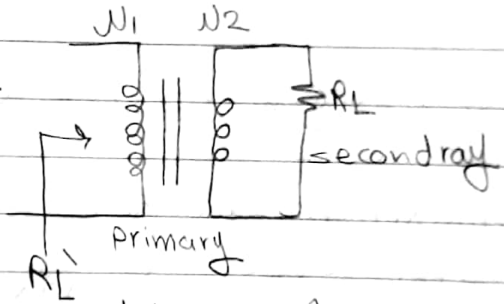


$$\frac{R_L}{R_L'} = \frac{V_2/I_2}{V_1/I_1} = \frac{V_2 I_1}{V_1 I_2} = \frac{N_2 N_2}{N_1 N_1} = \left(\frac{N_2}{N_1}\right)^2$$

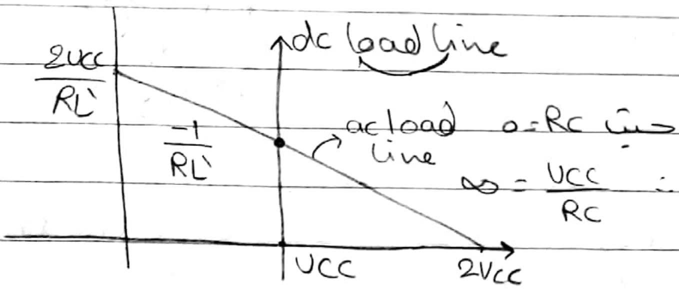
$$\frac{R_L'}{R_L} = \left(\frac{N_1}{N_2}\right)^2 = a^2$$

$R_L' = a^2 R_L$ ← effictive resistance.

S.C ← Tranformer الـ Dc في



$N_1 > N_2$ → step down



dc load line

يوصل الـ accuracy إلى 50%

$V_{ce\,p-p} = 2V_{cc}$

$\frac{V_{cc}^2}{2R_L'}$

$I_{c\,p.p} = \frac{2V_{cc}}{R_c}$

$P_{i(dc)} = V_{cc} I_{CQ} = V_{cc} * \frac{V_{cc}}{R_L'} = \frac{V_{cc}^2}{R_L'}$

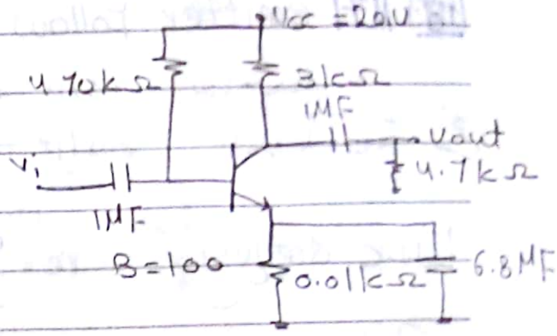
$P_{o(dc)} = \frac{V_{ce(p-p)}\, i_{c(p-p)}}{8} = \frac{V_{cc}^2}{2R_L'}$

$\frac{V_{cc}}{\sqrt{2}} \cdot \frac{V_{cc}}{R_L\sqrt{2}}$

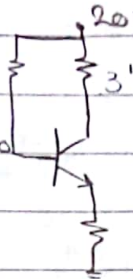
$\eta = 50\%$

4 Writ

## [16] Find fL




[1] dc analysis




$V_{CC} - I_B R_B - V_{BE} - I_E R_E = 0$

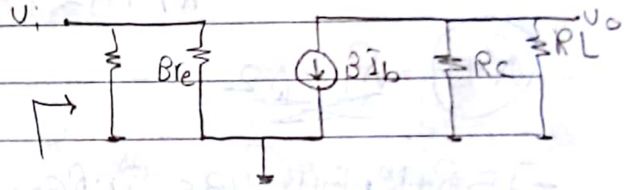
$20 - I_B\, 470 - 0.7 + (B+1) I_B R_E = 0$

$I_B = 33.8\,\mu A$

$I_E = (B+1) I_B = 3.752\,mA$

$r_e = \dfrac{V_T}{I_E} = 6.93\,\Omega$

[2] ac analysis




$R_{in} = R_B \parallel B r_e$

$A_V = \dfrac{-B i_b (R_C \parallel R_L)}{i_b B r_e} = \dfrac{-R_L \parallel R_C}{r_e}$

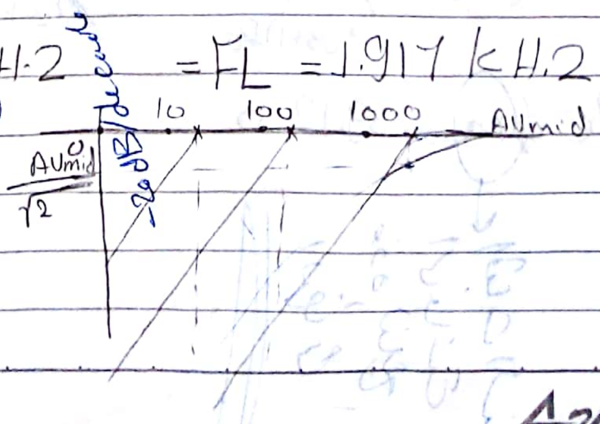
$R_o = R_C$

$R_{eq} = R_E \parallel \dfrac{(B r_e + R_B)}{(B)}$

$F_{LB} = \dfrac{1}{2\pi (R_S + R_i) C_S} = 116.93\ Hz$

$F_{LC} = \dfrac{1}{2\pi (R_o + R_L) C_C} = 20.67\ Hz$

$F_{LE} = \dfrac{1}{2\pi (R_{eq}) C_E} = 1.917\ kHz$ $= F_L = 1.917\ kHz$

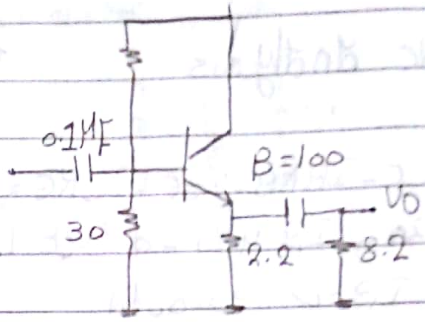


$R_{in} \uparrow\uparrow\uparrow \; R_{out}$ Report [18]

Date Subject

[18] [17] emitter follow = collector

[3] FL → $FL_B$ in/p = 71.92 Hz → $FL_C$ out/p = 193.16 Hz = FL

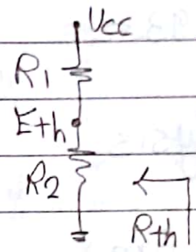


[1] Dc analysis $re = \frac{u_h}{I_E}$

$\beta R_E \geq 10 R_2$

$100 * 2.2 \geq 10 \times 30$

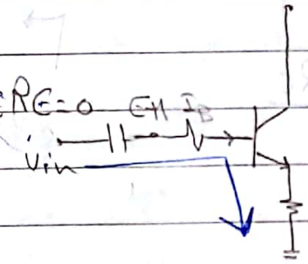
$22k \geq 300k$ Not statisfied



$E_{th} = V_B = V_{cc} * \frac{R_2}{R_1 + R_2}$

$R_{th} = R_1 // R_2$

$-I_B R_{th} + E_{th} - V_{BE} - I_E R_E = 0$

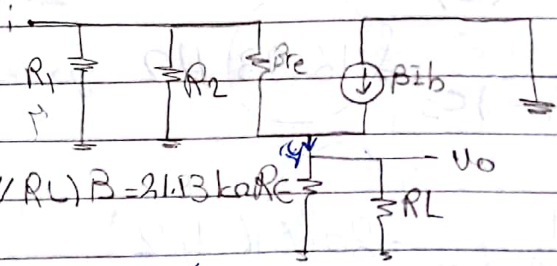


$I_B = 8.53nA$

$I_E = 0.86mA$

$re = 30.20\Omega$

[2] Ac analysis



$R_{in} = R_1 // R_2 // \beta re + (R_E // R_L)\beta = 21.13k\Omega$

$A_v = \frac{V_o}{V_i} = \frac{I_E (R_E // R_L)}{\beta re I_b + I_E (R_L // R_E)} = \frac{(\beta+1)(R_E // R_L)}{\beta re + (\beta+1)(R_E // R_L)} = \frac{R_E // R_L}{re + (R_E // R_L)} = 0.933$

$I_E \rightarrow (\beta+1) I_b$

$R_o = R_E // re = 39.12\Omega$

Date Subject (239)

8

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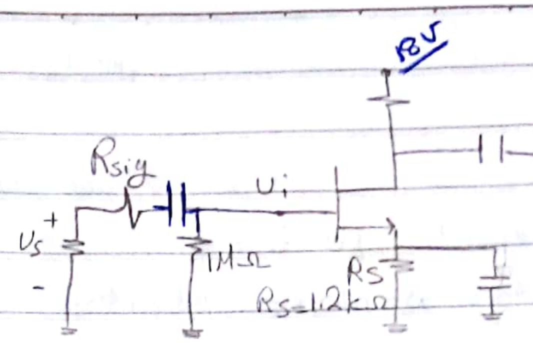
I) Dc analysis




$ID = IDss\left[1 - \frac{VGs}{Vp}\right]^2$

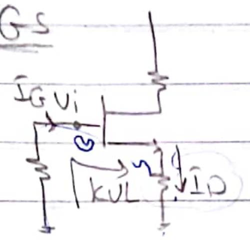
IDss → 6mA, Vp → −6

Biasing

$0 - VGs - ID\,Rs = 0$

$VGs = -ID\,Rs$ → 1.2kΩ

ID, VGs

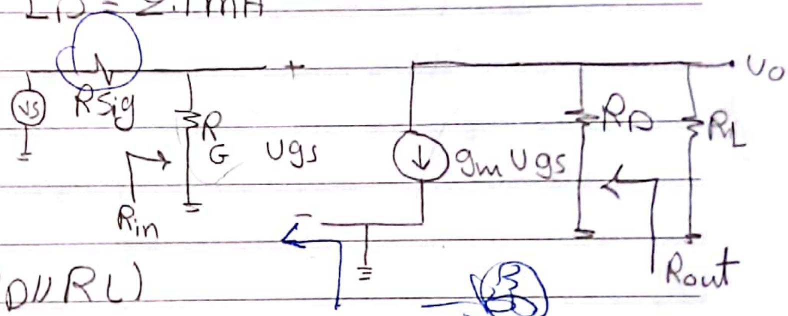



$g_{mo} = \frac{2IDss}{|Vp|} = \frac{2\times6\times10^{-3}}{|-6|} = 2m\Omega^{-1}$

$VGs = -2.45$

$g_m = g_{mo}\left[1 - \frac{|VGs|}{Vp}\right] = 1.18m\Omega^{-1}$

$ID = 2.1mA$




$R_{in} = RG // \infty = RG$

$AV = \frac{-g_m \cancel{Vgs}(RD//RL)}{\cancel{Vgs}} = -g_m(RD//RL)$

$Rout = RD$

Ref ← source Jno (eo=z-o) $= \frac{1}{g_m} // Rs$

0

19:30

IDss I

4 Write

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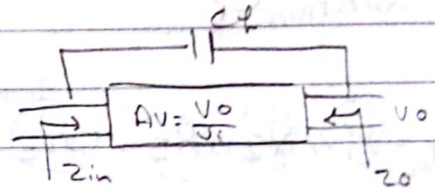
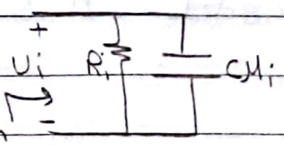
millier effect capacitance

For inverting amplifier (phase shift = 180°)
input and output capacitance increased by capacitance
Level sensitive To inter electrode capacitance between
input and output Terminals.




CMi

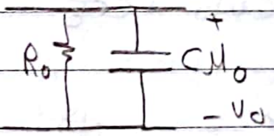



$CM_i = (1 - AV)\,C_F$

$CM_i = (1 - AV)\,C_f \rightarrow$

$CM_o = \left(1 - \frac{1}{AV}\right) C_f \rightarrow$

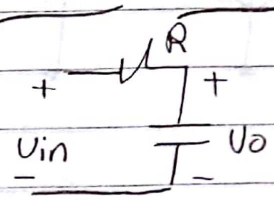
CMo




$CM_o = \left(1 - \frac{1}{AV}\right) C_F$

ندرس تأثير ال internal capci وال external مكثفة S.C

High Pass Filter



Date Subject

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[15,16] نقش

$n \to 10^{-9}$

$P \to 10^{-12}$

$F \to 10^{-15}$

$r_e = 28.46\,\Omega$

$A_V = -72.91$

$$F_{H_i} = \frac{1}{2\pi R_{th_{in}} C_i} \qquad F_{H_o} = \frac{1}{2\pi R_{th_o} C_o}$$

model مرسم الـ

$R_{th_i} = R_1 // R_2 // R_S // \beta r_e$

$R_{th_o} = R_L // R_C // \underset{\to \infty}{r_o} =$

$C_i = C_{M_i} + C_{W_i} + C_{bE} = (1 - A_V) C_{bC} + C_{W_i} + C_{bE}$

$C_o = C_{M_o} + C_{W_o} + C_{CE} = (1 - \frac{1}{A_V}) C_{bC} + C_{W_o} + C_{CE}$

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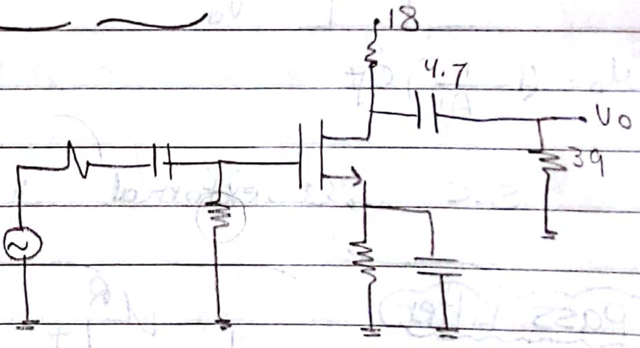
model من




$R_{th_i} = R_{Si} // R_{G2}$

$R_{th_o} = R_L // R_D$

$C_i = C_{W_i} + C_{GS} + (1 - A_V) C_{GD}$

$C_o = C_{W_o} + C_{DS} + (1 - \frac{1}{A_V}) C_{GD}$

$A_V = -2$

$g_m = 1.78\ m\Omega^{-1}$

$$F_{Hg} = \frac{1}{2\pi C_i R_{th_i}}$$

$$F_{HD} = \frac{1}{2\pi C_o R_{th_o}}$$

4 Writ

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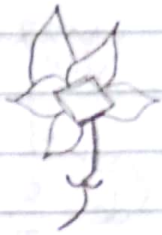
when $\eta = 50\%$ ← max efficiency

$$\eta = 50 \left[ \frac{V_{CE\,max} - V_{CE\,min}}{V_{CE\,max} + V_{CE\,min}} \right]^2 \%$$

$V_{CE\,max} \to V_{CEQ} + V_P$, $V_{CE\,min} \to V_{CEQ} - V_P$



## class B

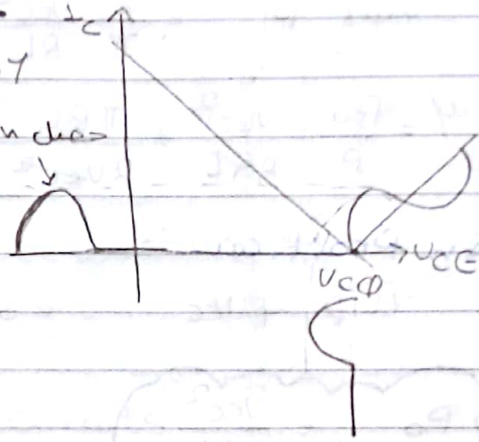
مفيش Baising يعني $I_B = 0$ وبالتالي Q هتاخد

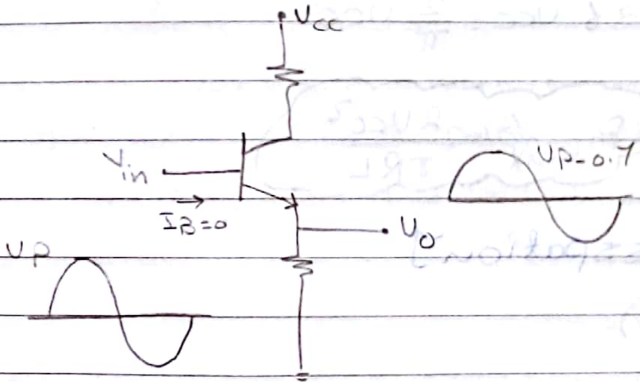
(puls) → لـ 0.7 علشان يبدأ يشتغل

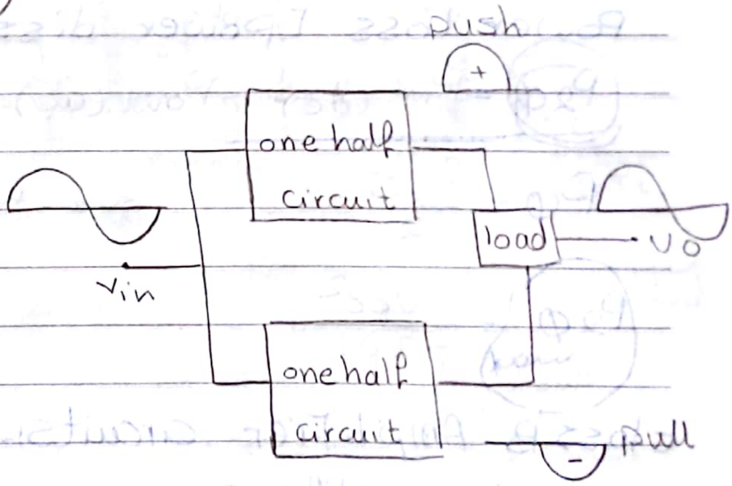
distortion يحدث

C.E inverting مفيش

$V_i = V_{out}$




$$\eta = \frac{P_{o\,(dc)}}{P_{i\,(dc)}}$$

$$I_{L\,d.c} = \frac{2}{\pi} I_P$$

$$P_{in} = V_{CC} * I_{CQ}$$

$$\therefore P_{in} = V_{CC} * \frac{2 I_P}{\pi}$$

class B = Push pull amplifier

$$\therefore P_o = \frac{V_{L(rms)}^2}{R_L} = \frac{V_{L(p.p)}^2}{8 R_L} = \frac{V_{Lp}^2}{2 R_L}$$

$$\eta = \frac{V_{LP}^2}{2 R_L} * \frac{\pi}{2 I_P V_{CC}} = \frac{\pi}{4} \frac{V_{LP}}{V_{CC}} * 100\%$$

→ max power consderation:-

$$\max P_{out}\Big|_{V_{LP}=V_{CC}} = \frac{V_{CC}^2}{2R_L}$$

$$I_{dc} = \frac{2}{\pi} I_P \quad \left(I_P \rightarrow \frac{V_{CC}}{R_L}\right) = \frac{2}{\pi} \cdot \frac{V_{CC}}{R_L}$$

$$\max P_i = \frac{2}{\pi} \frac{V_{CC}^2}{R_L}$$

$$\eta = \frac{P_o}{P_i} = \frac{V_{CC}^2}{2R_L} * \frac{\pi R_L}{2V_{CC}^2} = \frac{\pi}{4} * 100 = 78.53\%$$

In Practice:-

$$V_{LP} \neq V_{CC} \qquad = 0.636\, V_{CC} = \frac{2}{\pi} V_{CC}$$

$$P_{o\,max} = \frac{V_{CC}^2}{2R_L} \qquad P_{i\,max} = \frac{2V_{CC}^2}{\pi R_L}$$

Power Loss [power dissipation]

$$P_{2\phi} = P_{in(dc)} - P_{out(ac)}$$

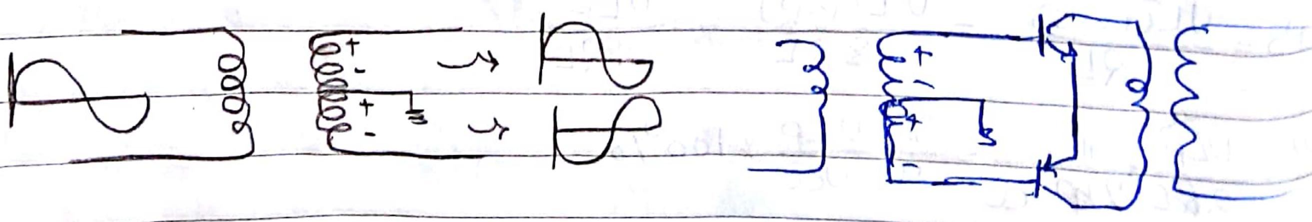
$$P_{\phi} = \frac{P_{2\phi}}{2} \leftarrow \text{one transistor.}$$

$$P_{2\phi\,max} = \frac{2V_{CC}^2}{\pi^2 R_L}$$

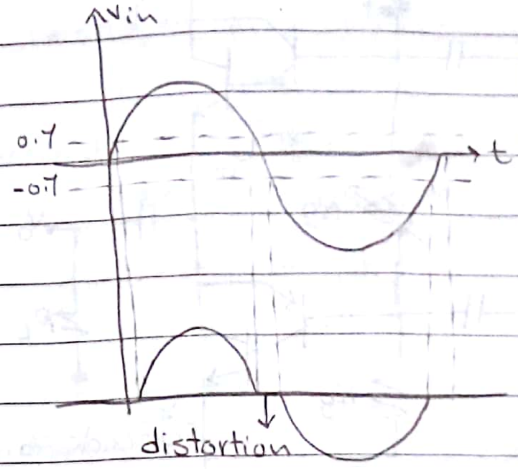
class B Amplifier circuits:-

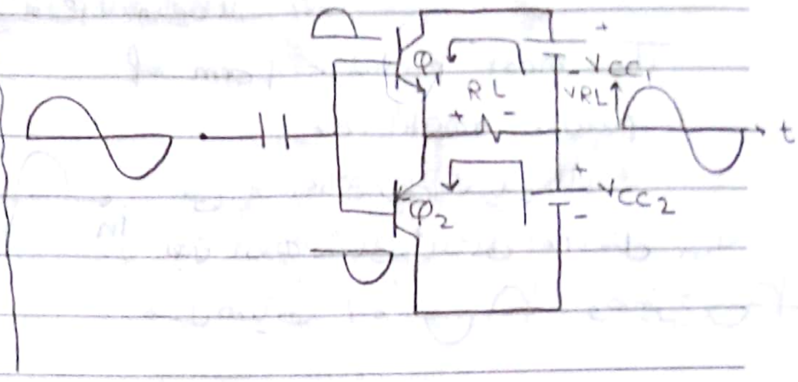
→ phase splitters

لوعاوز اشغل ال $2\phi$ (pnp, npn)



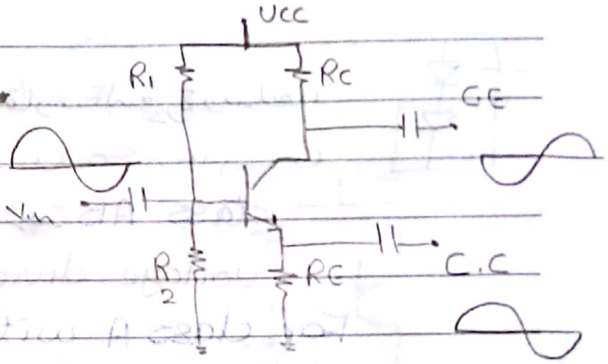
## [1] complementary symmetry circuit



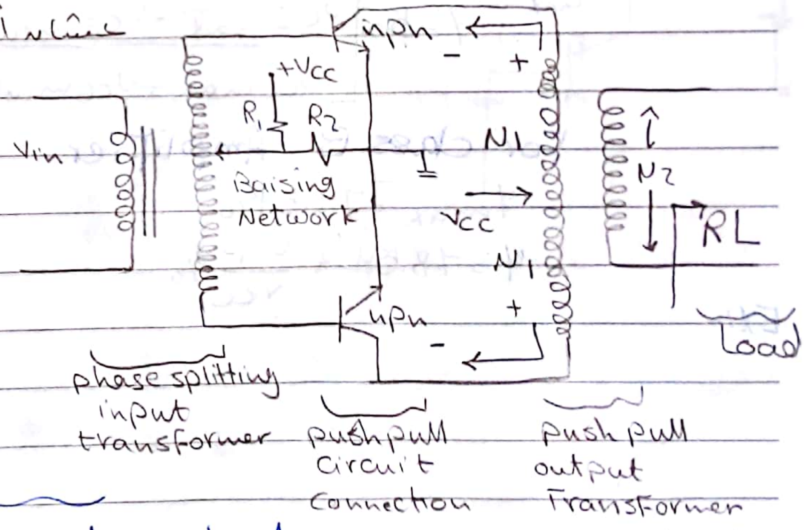

↳ class AB علشان كده هنستخدم

Baising علشان نعمل




## [2] Transform-coupled push pull circuits

matching علشان نطابق




$B_T = B_1 B_2$

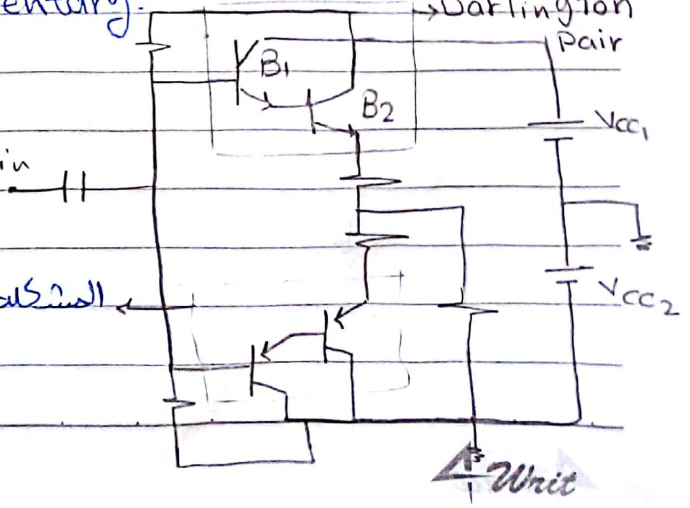
→ high current gain

→ out impedance ↓ in ↑↑

والـ out كـ PnP والديفضل الشكل ده

المشكلة إن الخرج على PnP

complementary

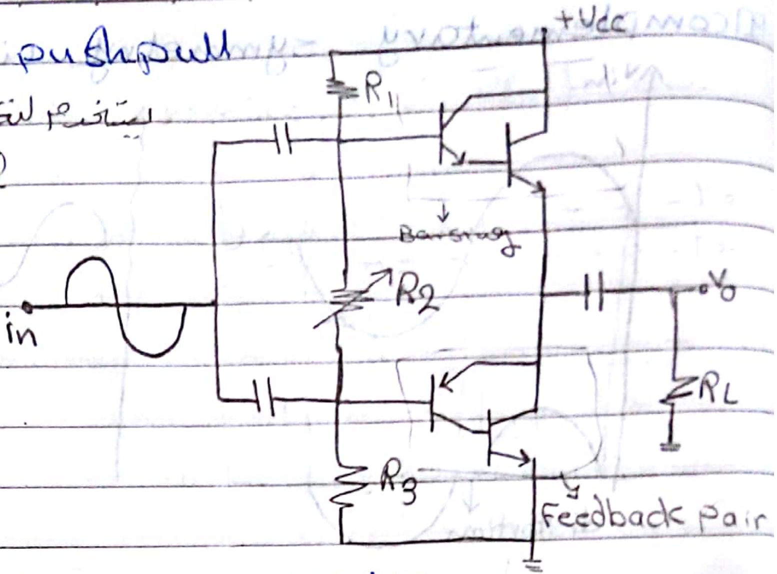


Date Subject

## [3] Quasi complementary pushpull

يستخدم لتعويض الـ ٥٠٠

The most popular Form of power amplifier.




في Baising بين فتيار

بين الـ Q شغال بالتالي أما دخل Vin

من هيأخد ٥٠٠ وهيخرج

← في نوع تاني نفس الرسم بس شيل المقاومة المتغيرة وبدلها ب compensating diode.

class AB → class B with littel Baising

voltage divider / two compensating diode

For class A with transformer coupling.

$\eta_{max} = 50\%$

$$\eta = 50 \left[ \frac{V_{CEmax} - V_{CEmin}}{V_{CEmax} + V_{CEmin}} \right]$$

For class B Amplifier

$\eta_{max} = 78.54\%$

$$\eta = 78.54 * \frac{V_{LP}}{V_{CC}} \%$$

EX:-

Date Subject lec

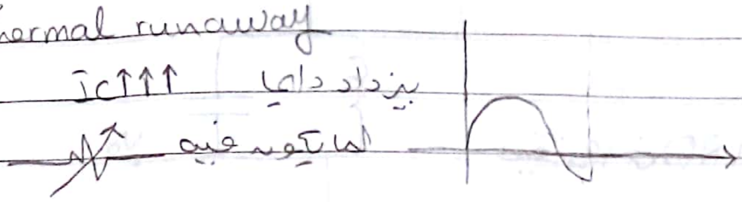
* الحرارة هتزود VBG وبالتالي يزداد ال Ic فيحرق الجهاز

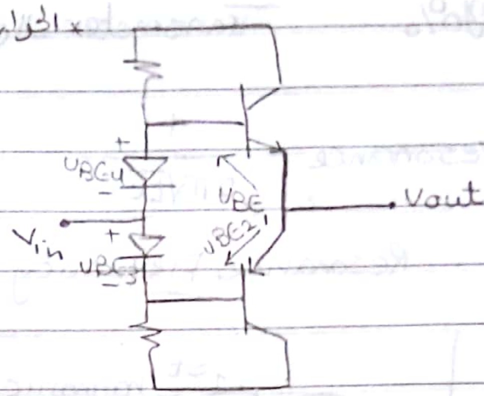
$I_C \alpha V_{BG}$

Thermal runaway

$I_C \uparrow\uparrow\uparrow$ يزداد دايما

الماكوم عليه





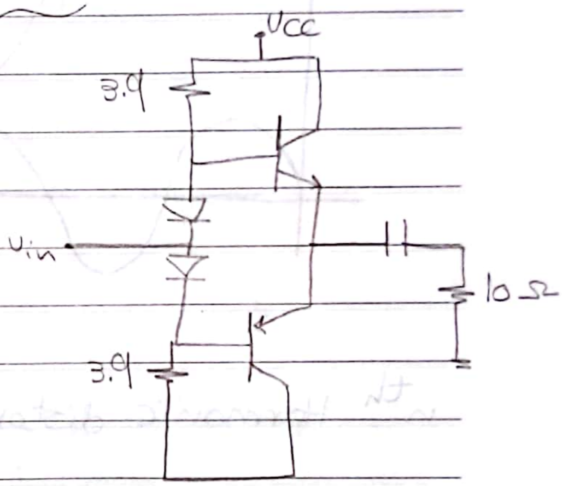

$V_{BE_1} + V_{BE_2} - V_{BG_3} - V_{BG_4}$

← حجم ال 2diode بيعملوا انه بيتحكم في ال heatdispation.

وبكدا Ic ← constant وبثبت فيه stable with tempreture.

what is quiscont collector current?

The maxefficiency.

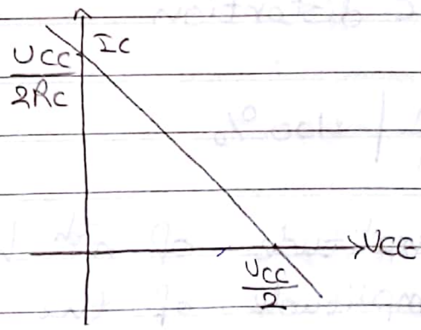



$$I_{Bias} = \frac{V_{cc} - 1.4}{2 * 3.9} = 2.38 mA$$

$$I_C \simeq I_B = 2.38 mA$$

$$I_{C(P)} = \frac{V_{cc}}{2R_c} = \frac{20}{2*10} = 1A$$

max value




$$I_{dv} = \frac{I_{C(P)}}{\pi} = \frac{1}{\pi} = 0.318 A$$

total current Drain $= 2.38 + 0.318$

$$P_{dc} = V_{cc} * I_{dc} = 20 * 0.32 = 6.4 W$$

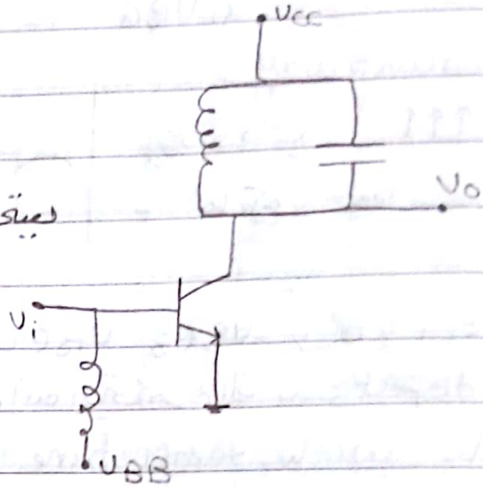
$$P_{dc} = \frac{V_{cc}^2}{8R_L} = \frac{(20)^2}{8*10} = 5 watt$$

$$\eta = \frac{P_o}{P_i} * 100 = 78.1\%$$

4 Write

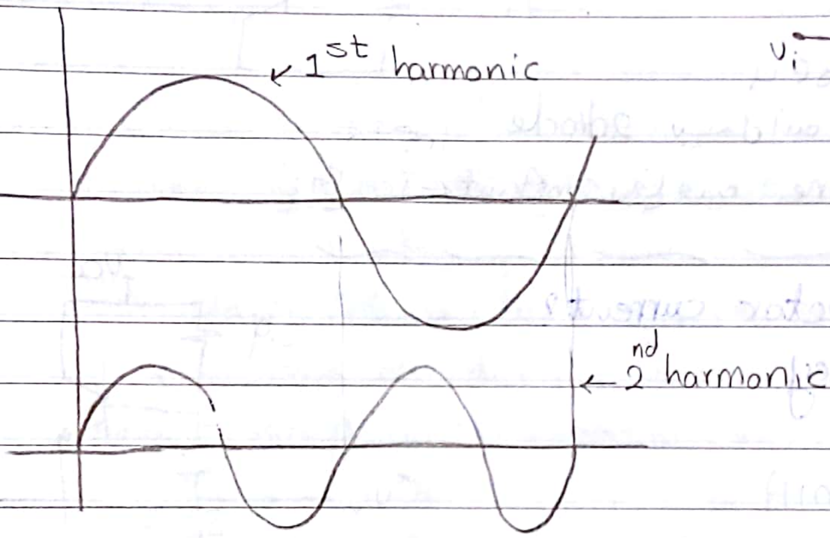
## Class C Amplifier.

$\eta = 90\%$ Transmeter بيستغل ويكبر لدرجة موجودة في ال




$$F_{resonance} = \frac{1}{2\pi\sqrt{LC}}$$

Resonance Frequancy (RF) بيتغير فيها




وهكذا

## $n^{th}$ Harmonic distortion

$$D_n = \left|\frac{A_n}{A_1}\right| \times 100\%$$

$A_n \rightarrow$ The Amplitude of $n^{th}$ harmonic

$A_1 \rightarrow$ the Amplitude of the Funtamental.

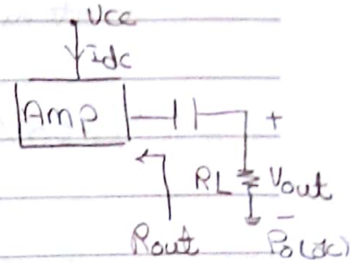
Total harmonic distortion (T.H.D)

$$THD = \sqrt{D_2^2 + D_3^2 + D_4^2 + \cdots} \times 100\%$$

# Power Amplifier

**Factors affect on power Amplifier:-**

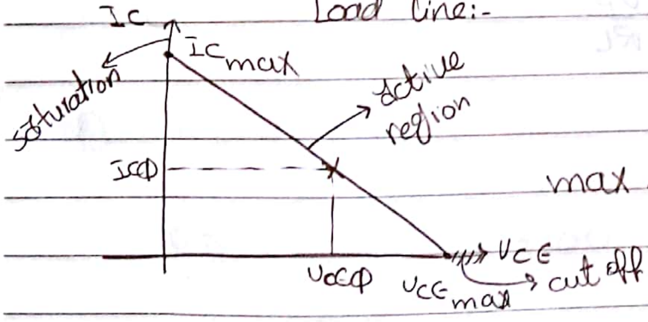
- $\eta \uparrow\uparrow = \frac{P_{o(dc)}}{P_{i(dc)}}$
- power dissipation "consumption" ↓↓
- impedance matching between Amp o/p , Load




**Types of Amp:-**

1- A
2- B
3- AB
4- C
5- D

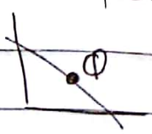
## Class A



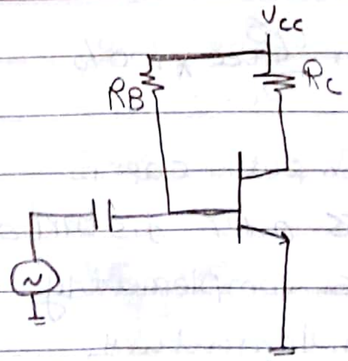

max swing → لـ Ic و VCE

max swing ← بدال Q point و بدال max swing

operating point Q




VCE , IC الإحداثيات




operating cycle → 360°

$\eta$ → 25% - 50%

$\eta = \frac{P_{o(dc)}}{P_{i(dc)}}$

$P_{i dc} = V_{cc} I_{dc}$ → $I_{CQ}$

$P_{o(dc)} = V_{CE_{rms}} I_{C_{rms}} = I_{rms}^2 R_L = \frac{V_{rms}^2}{R_L}$

$V_{rms} = \frac{V_P}{\sqrt{2}}$ $\qquad V_{p,p} = 2V_P$

$V_{P_{max}} = V_{cc}/2$

$\eta_{max} = 25\%$

$\boxed{R_L = 2R_L'}$



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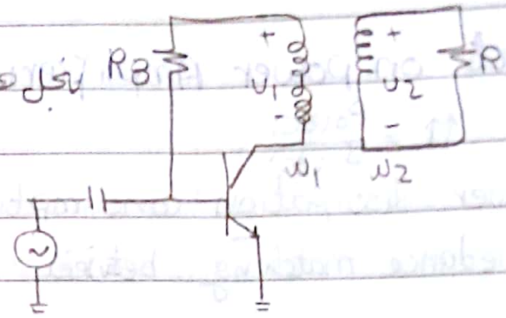
class A with coupled Transformer.

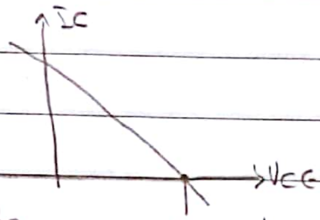
matching بنحل مشكلة ال



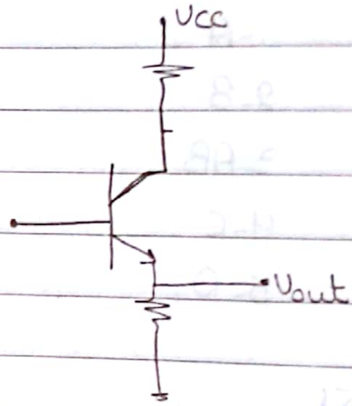

$\eta = 50\%$

## class B

Q point




operating < 180




$$\eta = \frac{P_o(dc)}{P_i(dc)}$$

$P_i(dc) = V_{CC}\, I(dc)$ $\quad I_{dc} = \frac{2}{\pi} I_p = \frac{2}{\pi}\frac{V_P}{R_L}$

$$P_o(dc) = \frac{V_{rms}^2}{R_L} = \frac{V_{LP}^2}{2R_L}$$

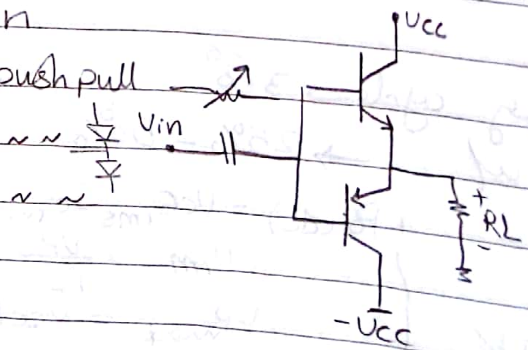
$$\eta = \frac{\pi}{4}\frac{V_{LP}}{V_{CC}} \times 100\%$$

$$\eta_{max} = \frac{\pi}{4} \times \frac{\cancel{V_{LP}}\, V_{CC}}{V_{CC}} \times 100\%$$

→ push pull class B

cross over distortion

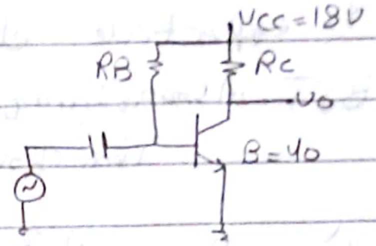
حل مشكلة
- → quasi complementary push pull
- → complementary
- → Transform



[12.2] input power

[1] o/p Power

input signal base current (5mA) → AC




$$I_{BQ} = \frac{V_{CC} - V_{BE}}{R_B} = \frac{18 - 0.7}{1.2} =$$

$$\therefore I_{CQ} = \beta I_{BQ}$$

$$P_{in(dc)} = V_{CC} I_{dc}$$

$$I_{C\,rms} = \beta I_{B\,rms} = 200mA$$

$$P_{o(dc)} = I_{C\,rms}^2 \, \cancel{R_L}\ R_C$$

[2] ↓RB نفس المسألة تت بـ

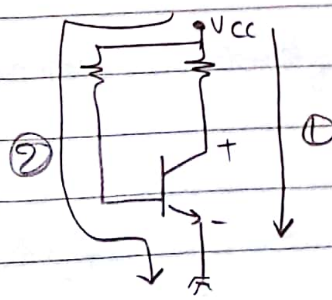
$I_B \uparrow \rightarrow P_{in} \uparrow$

[3] $\eta = \frac{P_o}{P_{in}} \times 100$

$$25\% = \frac{1.5}{P_{i(dc)}} \times 100$$

$P_{i(dc)}$

← لو عاوز اجيب الـ Q point




$V_{CC} - I_C R_C = V_{CE}$ (VC)

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

Power consumption $= P_{i(dc)} - P_{o(dc)}$

5 coupled Transeformer

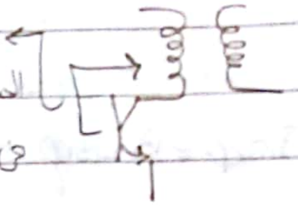
25:1

4 Ω load

∴ effective elc load

BJT المقاومة اللي بيشوفها ال

في ال Transformer



$$\frac{R_L'}{R_L} = a^2 = \left(\frac{N_1^2}{N_2^2}\right)$$

$$R_L' = R_L \times a^2$$

6 $R_L = 8$

$R_L' = 8$

$R_L' = a^2 R_L$

$8k = a^2 \, 8$

$a^2 = 1000$

$a = \sqrt{1000}$

7 $R_L = \frac{16}{4} = 4\,\Omega$

$8k = a^2 \, 4$

$a^2 = 2000$

$a = \sqrt{2000}$

8 Transeformer coupled class A

$R_L = 16\ \Omega$

$3.87 : 1$

$N_1 : N_2$ $V_{cc} = 36\ V$

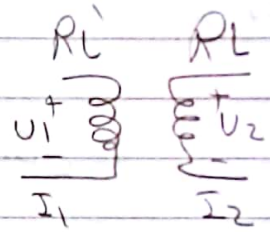
circuit drives 2W To the load

$\rightarrow P_{o\,dc}$

a) $P_{dc}$ across primary

$P_{dc} = P_{o\,dc} = 2W$

b) $V_{L\,dc}$ across Primary




$P = \frac{V_P^2}{R_L'}$ $R_L' = a^2 R_L$

$V_P^2 = 2 * a^2 R_L = 2 * (3.87) * 16 =$

c) $V_{L\,dc}$

$P = \frac{V_L^2}{R_L}$

$V_L^2 = 2 * 16 = 32$

$V_L = \sqrt{32}$

d) Irms primary, secondry

$P_P = I^2 R_L'$

$I^2 = 2 / (a^2 R_L)$

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9 فاضل ال 8

$I_{CQ} = 150\ mA$

$\eta =$

$$\eta = \frac{P_o(dc)}{P_i(dc)} * 100 = 37\%$$

$P_i(dc) = V_{cc} * I_{dc}$
$36 * 150mA =$

$P_{o(dc)} = 2$ watt

10 شرح

11 شرح

12 class B

22V peak signal To 8 Ω load

$V_{CC} = 25V$

$P_{in}, P_o, \eta$

$P_{in} = V_{cc} * I_{dc}$

$25 * \frac{2}{\pi} \frac{V_P}{R_L} = 25 * \frac{2}{\pi} * \frac{22}{8}$

$$P_o = \frac{V_P^2}{2R_L} = \frac{(22)^2}{8}$$

$$\eta = \frac{P_{o\,dc}}{P_{i(dc)}} * 100 = \frac{\pi}{4} * \frac{V_P}{V_{CC}} = \frac{\pi}{4} * \frac{22}{25} =$$

Scanned by CamScanner

13

$P_{i(dc)\,max} = V_{CC} * I_{C\phi}$

$V_{CC} * \frac{2}{\pi} \frac{V_P \rightarrow V_{CC}}{R_L}$ $\quad \frac{2}{\pi} * \frac{(23)^2}{8}$

$P_{o(dc)} = \frac{V_{CC}^2}{R_L}$

$\eta = \frac{\pi}{4} * \frac{V_{CC}}{V_{CC}} * 100 = 78.54\%$

14 $\eta \rightarrow$ class B

$V_{CC} = 22$

$R_L = 4$

o/p voltage peak $= 20$

4

$P_i = V_{CC} * \frac{2}{\pi} \frac{(I_P) \rightarrow V_P}{R_L} = 22 * \frac{2}{\pi} * \frac{20}{4}$

$P_o = \frac{(20)^2}{2(4)}$

8

report

Date Subject

16

class B

ⓐ $\max P_{o(dc)} = \frac{V_L^2}{2R_L} = \frac{V_{cc}^2}{2R_L} = \frac{30^2}{2\times 8} = 56.25\ W$

ⓑ $\max P_{i(dc)} = V_{cc} I_{dc} = V_{cc} * \frac{2}{\pi} \times \frac{V_{cc}}{R_L} = \frac{2V_{cc}^2}{\pi R_L}$

$= \frac{2\times 30^2}{\pi \times 8} = 71.6197\ W$

ⓒ $\eta = \frac{P_{o(dc)}}{P_{i(dc)}} = \frac{56.25}{71.619} * 100\% = 78.5398\%$

⇒ ⓓ $P_{2Q} = \frac{2V_{cc}^2}{\pi^2 R_L} = \frac{2(30)^2}{\pi^2\, 8} = 22.797\ W$

17

$P_i = V_{cc} * I_{dc} = V_{cc} * \frac{2}{\pi} \frac{V_P}{R_L}$ $V_P \rightarrow V_{rms}\sqrt{2}$ $V_{rms} = \frac{V_P}{\sqrt{2}}$

$P_i = 30 * \frac{2}{\pi} * \frac{8\sqrt{2}}{8} = 27.0094\ W$

$P_o = \frac{V_{rms}^2}{R_L} = \frac{8^2}{8} = 8\ W$

$\eta = \frac{P_o}{P_i} = \frac{8}{27.009} * 100\% = 29.6192\%$

⇒ $P_{2Q} = P_i - P_o$

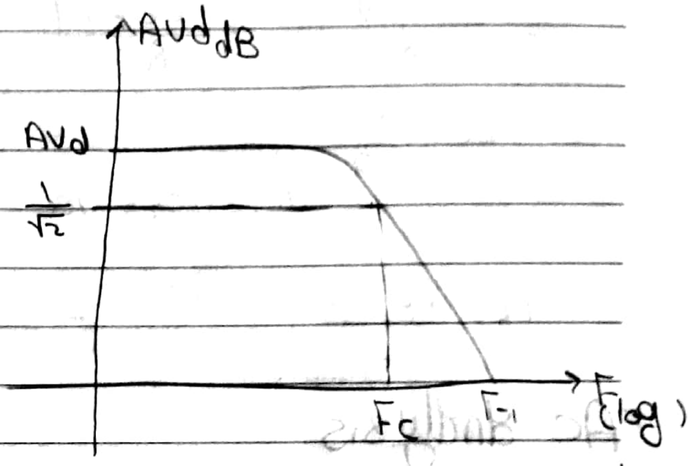
$= 27.0094 - 8 = 19.0094\ W$

# *op. amp

## [1] Avd differential oplooping :-

$V_o = (V^+ - V^-) A_{vd}$

ideally $A_{vd} = \infty$




(gain x Bw = const)
$R_F$ ,

(adv of RF)

1- Reduce gain (under control)
2 increase Band width
3 increase Rin
4- Decrease $R_o$

$F_1$: unity gain band width

## [2] A command mode :-

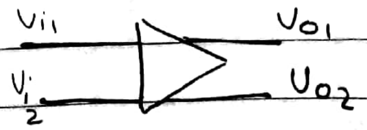
بدخل 2input بنسب ثابتة noise

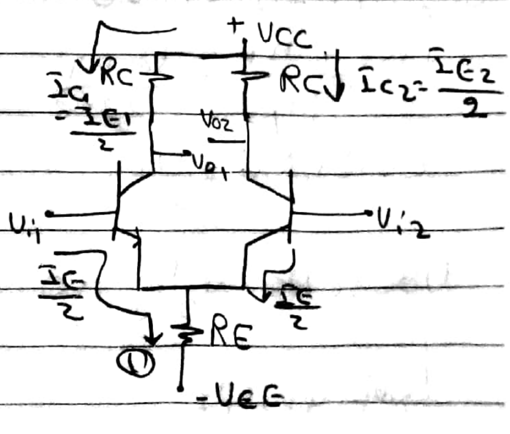
ideal → 0
inpractice → very small

$$CMRR = 20\log \frac{A_{vd}}{A_{cm}}$$

$$CMRR = \frac{\infty}{0} = \infty \leftarrow \text{ideal}$$

## Differential amplifier



# Dc analysis:-

KVL 1:-

$V_E = 0 \quad V_{BE} = -0.7\,V$

$$I_E = \frac{V_E-(-V_{EE})}{R_E} = \frac{V_{EE}-0.7}{R_E}$$

$$I_{C_1} = I_{C_2} = \frac{I_E}{2}$$

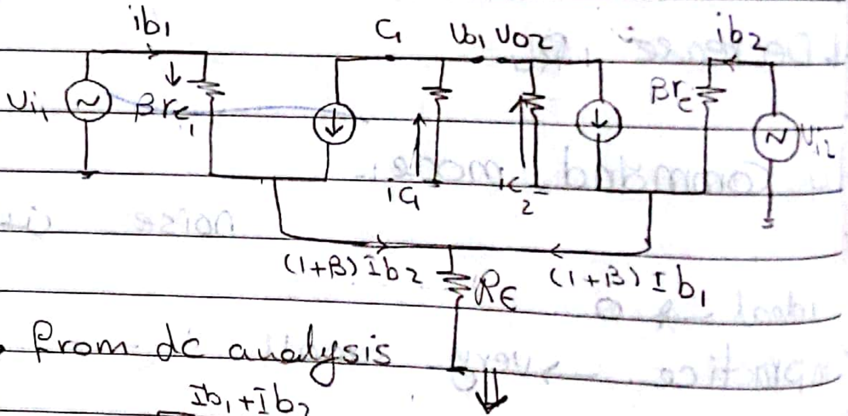
$$V_{C_1} = V_{C_2} = V_{CC} - I_C R_C = V_{CC} - \frac{I_E}{2} R_C$$

10:30
1:30

$$r_e = \frac{26\,mV}{I_E}$$

# Ac analysis

## [1] Single ended $V_{i2}=0$




Assume that $Q_1, Q_2$ are well matched.

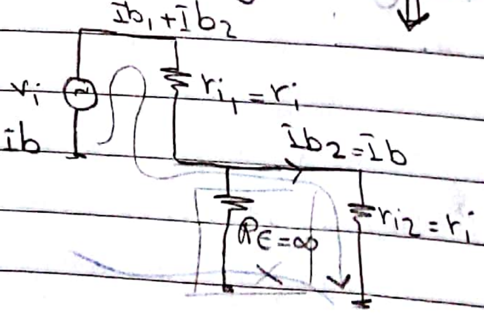
$I_{b1} = I_{b2} = I_b$

$r_{i1} = r_{i2} = r_i = \beta r_e \rightarrow$ from dc analysis

For simplification

$R_E = \infty$

Partial circuit for calculating $i_b$




applying KVL:-

$V_{in} - r_i I_b - r_i I_b = 0$

$$I_b = \frac{V_{in_1}}{2 r_i} = \frac{V_{in_1}}{2\beta r_e} \qquad \beta_1 = \beta_2 = \beta$$

$$I_C = \beta I_b = \frac{V_i}{2 r_e}$$

$$V_o = I_C R_C = \frac{V_i}{2 r_e} R_C = \frac{R_C}{2 r_e} V_{in}$$

$\hookrightarrow$ of $Q_1, Q_2$

single ended voltage gain

$A_V = \frac{V_o}{V_i} = \frac{R_C}{2r_e}$

AV of one stage in op-Amp
Not the AV of op-Amp total.

[1]

$\beta = 75$

$r_{i_1} = 20k\Omega$

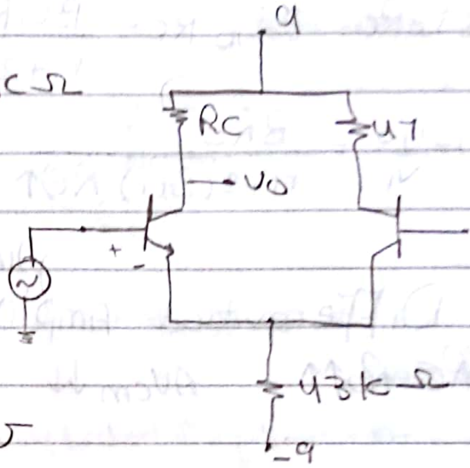
$V_o = -I_C R_C = \frac{V_i}{2r_e} R_C$

$r_i = \beta r_e$

$20\times10^3 = 75\, r_e$

$r_e = 266.6\,\Omega$

$V_o = \frac{2\times10^{-3}}{2*266.6} * 47\times10^3 = 0.17V$




[2] Double ended Ac Voltage gain

By similarity

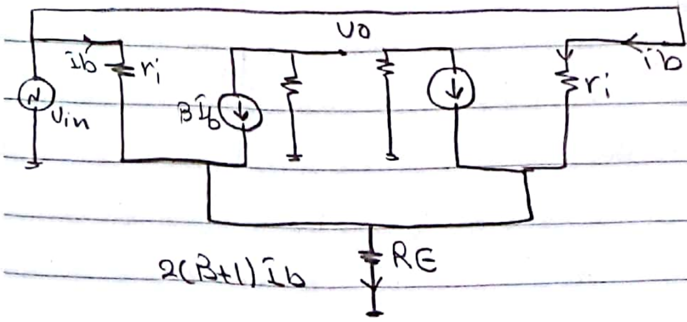
إثبات عليك

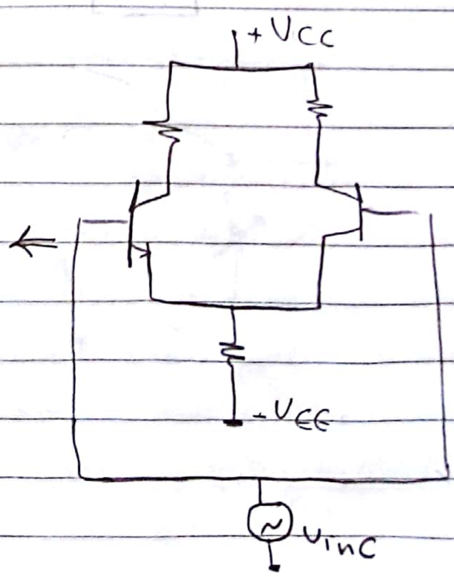
$A_d = \frac{V_o}{V_d} = \frac{R_C}{r_e}$

$V_d = V_{i_1} - V_{i_2}$

[3] Common mode

Ac model.



$$I_b = \frac{V_i - 2(\beta+1) I_b R_E}{r_i}$$

$$i_b = \frac{v_i}{r_i + 2(\beta+1) R_E}$$

$$V_o = I_c R_c = \beta I_b R_c = \frac{\beta V_i R_c}{r_i + 2(\beta+1) R_E}$$

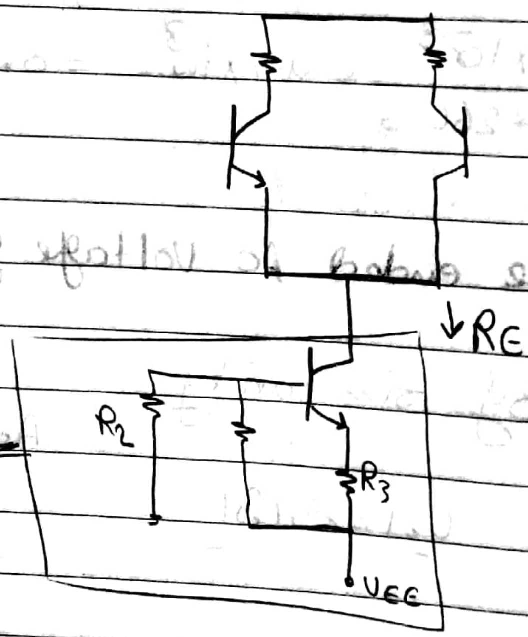
$$\downarrow\ A_v = \frac{V_o}{V_i} = \frac{\beta R_c}{r_i + 2(\beta+1) R_E \uparrow}$$

مطلع صغير

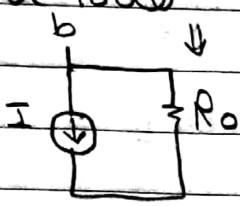
معناه $R_E$ كبيرة جدا لما ت $A_V$ تقلل

Differential Amplifier with constant current sou

$R_E = R_o \uparrow\uparrow$ $\quad A_{Vcm} \downarrow\downarrow$



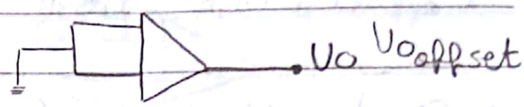

active load



# op-amp specifications - Dc offset parameters

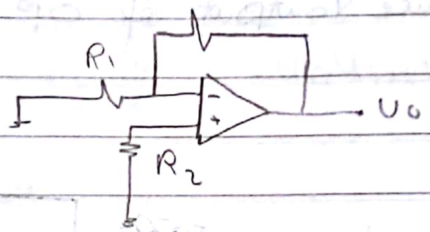
## offset current and Voltage:-

### ① offset voltage




$\boxed{\text{ideally } V_{o\,offset} = 0}$

$\boxed{\text{Practice} \simeq 26\ mV}$

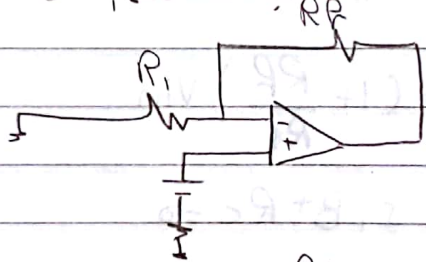


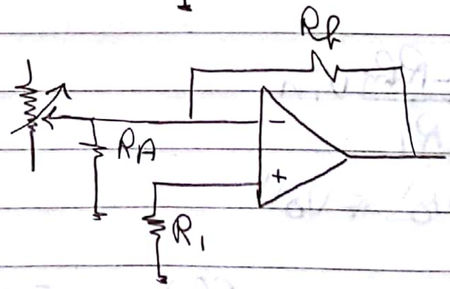

بسبب الـ stage الداخلية

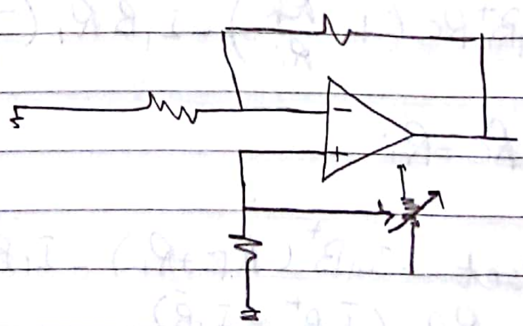
$V_{I\,offset}$ → موجودة في Data sheet.

$V_{I\,offset}$: الجهد المطلوب الداخل على الدائرة لجعل $V_{o\,offset}$ = صفر

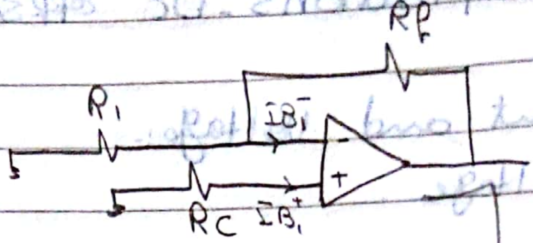
$$V_o = \left(1 + \frac{R_f}{R_1}\right) V_{in} \Leftarrow$$



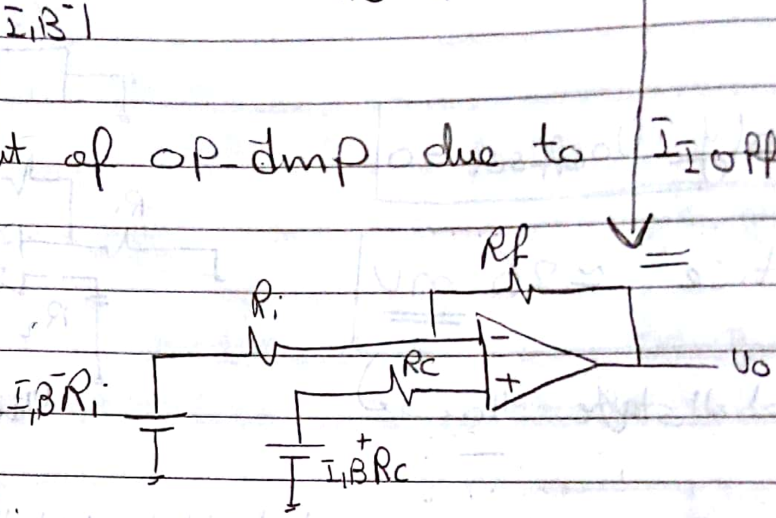
## ② offset current




$I_{Bias} = \frac{I_1B^+ + I_1B^-}{2}$

$I_{ioffset} = |I_1B^+ - I_1B^-|$

⇒ Deduce Voutput of op-amp due to $I_{Ioffset}$




$V_o' \Rightarrow \quad I_1B^-R_1 = 0$

$V_o' = \left(1 + \frac{Rf}{R_1}\right) Vin$

$V_o'' \Rightarrow \quad I_1B^+Rc = 0$

$V_o'' = \frac{-Rf}{R_1} Vin$

$V_o = V_o' + V_o''$

$V_O = I_1B^+Rc\left(1 + \frac{Rf}{R_1}\right) - I_1B^-R_1\left(\frac{-Rf}{R_1}\right)$

$Rc = R_1$

$V_{o\,offset} = I_1B^+(R_f + R_1) - I_1B^-Rf$

$= Rf\,(\underbrace{I_1B^+ - I_1B^-}_{I_{IO}})$

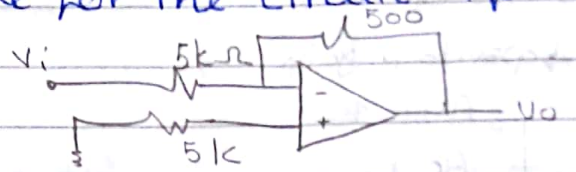
$V_{o\,offset} = I_{IO}\,Rf$

$V_{o\,offset} = V_{o\,offset}$ due to $V_{IO}$
$+ V_{o\,offset}$ due to $I_{IO}$

Find the total offset voltage for the circuit if

$V_{IO} = 4\,mV$

$I_{IO} = 150\,nA$




$V_{o\,offset}$ due to $V_{IO} = V_{IO}\left(1 + \frac{R_f}{R_i}\right) = 404\,mV$

$V_{offset}$ due to $I_{IO} = I_{IO} R_f$

$V_{o\,offset} = \boxed{\phantom{x}} + \boxed{\phantom{x}}$

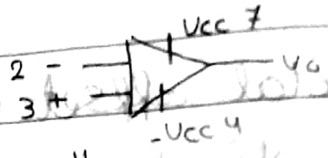
$I_{IB}^{+} = I_{IB} + \frac{I_{IO}}{2}$

$I_{IB}^{-} = I_{IB} - \frac{I_{IO}}{2}$

# OP- Amp

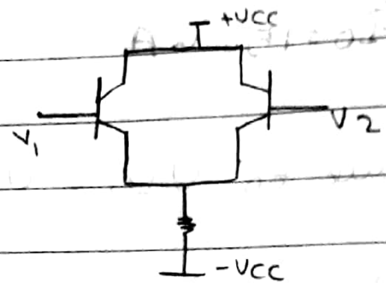
Differential amplifier

$V_o = A_d(V^+ - V^-)$

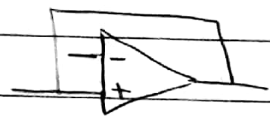



$A_d \rightarrow$ open loop gain

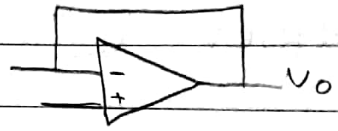
Datasheet ⇒
- AV ↑
- Ac ↓
- Ri ↑↑
- Ro ↓↓




op-amp with feedback:-



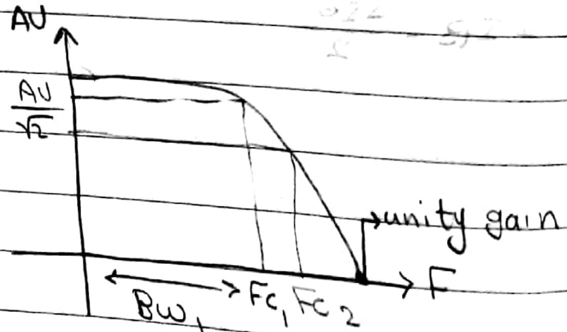

+ve feeback
oscillitor




-ve feedback
amplifier

$A_{cl} \rightarrow$ closed loop gain.
with feedback

DataSheet
- AV ↓↓
- Rin ↑↑
- Ro ↓↓
- BW ↑↑




Gain Bandwidth product:-

AV * BW = constant

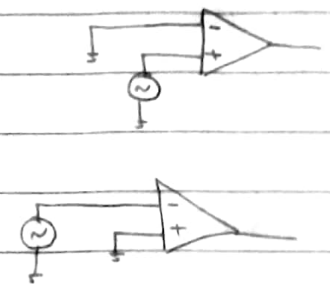
$AV \propto \frac{1}{BW}$

$Fc_1 \rightarrow BW_1$

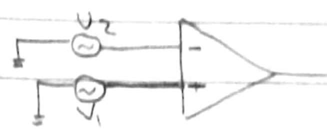
$Fc_2 \rightarrow BW_2$ ↑↑

ch11 [illegible]

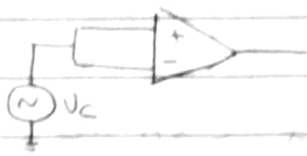
input signal models:-



single ended




Double ended




$V_o = A_c V_{ic}$

common mode

$A_c \downarrow$

Ex:- noise

op-amp specifications:-

Dc offset → offset voltage
└→ offset current

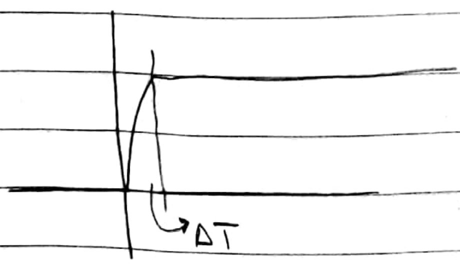
Common mode rejection ratio:-

$A_c \rightarrow V_o = A_c V_c$

$A_d \rightarrow V_o = A_d \Delta V$

$$CMRR = \underbrace{\frac{A_d}{A_c}}_{\text{نسبة}} \rightarrow \underbrace{20 \log \frac{A_d}{A_c}}_{dB}$$

slow rate $= \dfrac{\Delta v_{out}}{\Delta t}$




Δt ← مدة زمنية قصيرة

slow rate ← قيمة كبيرة

5,6,7 NON inverting

Sheet 24,17

Date Subject

[1]

$V_o = \frac{-R_f}{R_1} V_{in}$

[2] $R \nearrow$ 10 Ω, 10 kΩ

$V_{o1} = \frac{-R_f}{R_1} V_{in}$ $A_V = \frac{-R_f}{R_1} = \frac{-500}{10} =$

$V_{o2} = \frac{-R_f}{R_1'} V_{in}$ $A_V = \frac{-R_f}{R_1'} = \frac{-500}{20} =$

$\frac{-500}{20} < A_V < \frac{-500}{10}$

$-25 < A_V < -50$

[3]

$V_o = \frac{-R_f}{R_1} V_i$

$2 = \frac{-1\times10^5}{20\times10^3} V_i$ $V_i = V$

[4] $V_o = \frac{-R_f}{R_1} V_{in}$ $= \frac{-200}{20} V_i$

0.1 0.5

$V_o = -1$ $V_o = -5$

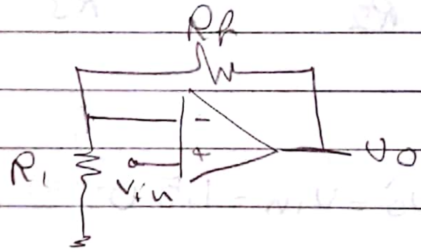
Date Subject

[8] $V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$

[9] $V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$

[11] $V_o = V_i$ matching , buffer

$V_o = \left(1 + \frac{R_f}{R_1}\right) V_{in}$




$R_f = 0$ S.C

$R_1 = \infty$ O.C

$V_o = (1+0)\, V_{in}$

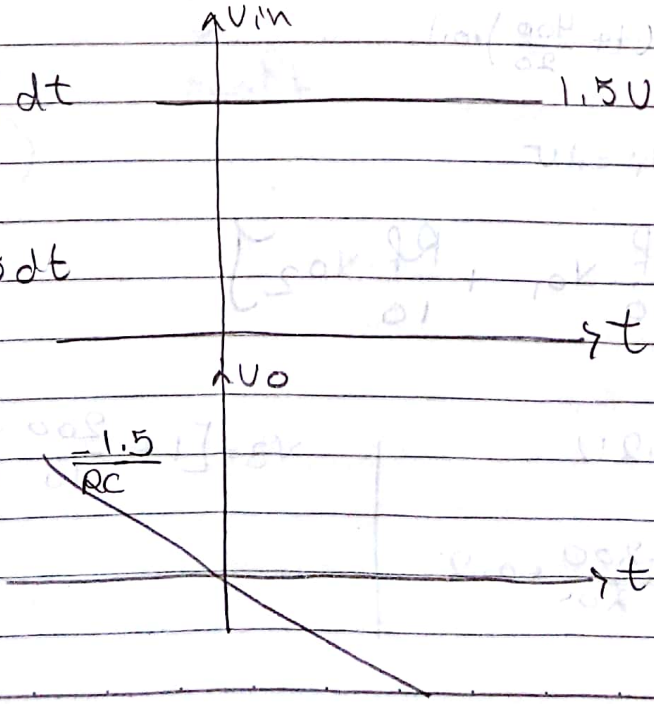
[16] sketch

integrator

$\frac{-1}{RC}\int V_{i(t)}\, dt$

$V_o = \frac{-1}{200k \times 0.1\mu}\int 1.5\, dt$

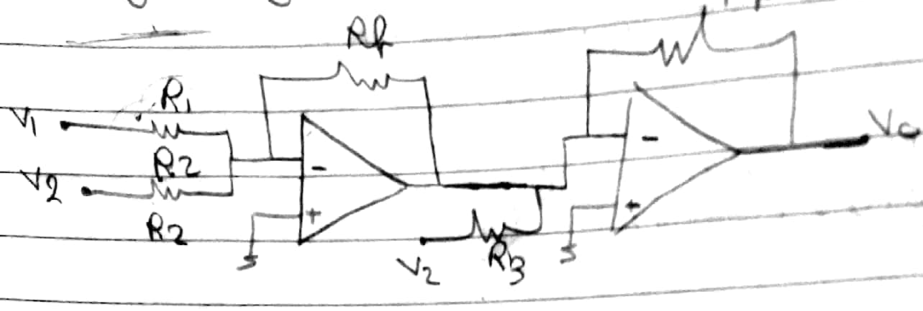
$\frac{-1.5}{RC} t$



Sol

$V_o = V_1 - 2V_2 + 3V_3$

Design by 2 op-amp




$\frac{R_f}{R_1} = 1$

$\frac{R_f}{R_2} = 2 \qquad \frac{R_f}{R_3} = 3$

$\boxed{12}$

$V_o' = V_{in} = 1.5\,V$

$V_o = \frac{-R_f}{R_1} V_o' \qquad = \frac{-100}{20} * 1.5$

$\boxed{13}$ $V_{o1} = (1 + \frac{400}{20}) * 0.1$

$V_{o2} = V_i = 1\,V$

$V_o = -\left[\frac{R_f}{20} V_{o1} + \frac{R_f}{10} V_{o2}\right]$

$\boxed{14}$ $V_{o1} = 0.2\,V$

$V_2 = \frac{-200}{20} * 0.2$

$V_3 = \left[1 + \frac{200}{10}\right] * 0.2$

Date Subject

**15**

$$V_{o_1} = -\left[\frac{600}{15} * 0.25m - \frac{600}{30} * 0.20mV\right]$$

$$V_{o_2} = -20mV$$

$$V_o = -\left[\frac{300}{30} * V_{o_1} + \frac{300}{15} * V_{o_2}\right]$$

**23**

$$CMRR = 20 \log \frac{A_d}{A_C}$$

$$A_d = \frac{V_o}{V_{id}} = \frac{20m}{1m} \quad \Big| \quad A_C = \frac{V_o}{V_c} = \frac{20\mu}{1\mu}$$

**16**

$$V_{o_{off}} = V_{o\,offset} + V_{o\,offset}$$

$V_{IO} \rightarrow A\,V_{IO} \rightarrow \left(1 + \frac{R_f}{R_1}\right)$

$I_{IO} \rightarrow I_{IO} R_f$

**24**

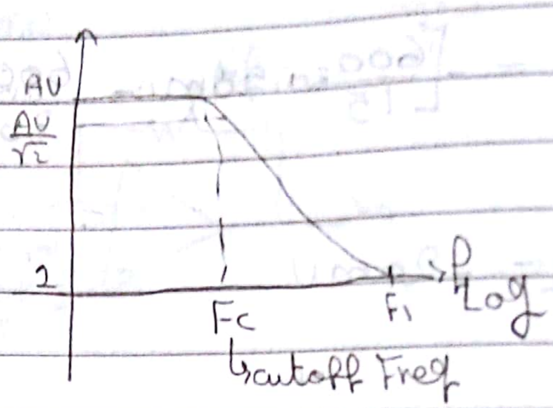
# op-Amp Frequancy Parameters

gain * BW = const

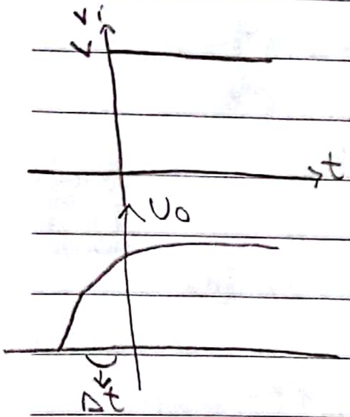
$F_1 = B =$ unity gain BW

$F_1 \times 1 = A_{VD} \times F_c$

$F_1 = A_{VD} * F_c$




**Slow rate** :- max rate at which op-amp output can change (V/μs)




$$SR = \frac{\Delta V_o}{\Delta t} (V/\mu s)$$

**problem**:- op-amp SR = 2V/μs what is the max closed loop voltage gain that can be used when the input signal varies by 0.5 V in 10μs

$A_{V_c} * V_{in} = V_{out}$

$A_{V_c} \frac{dv_i}{dt} = \frac{dv_o}{dt}$

$A_{V_c} = \frac{dv_o}{dt} \div \frac{dv_i}{dt} = 2 * \frac{10}{0.5}$

maximum signal frequancy:-

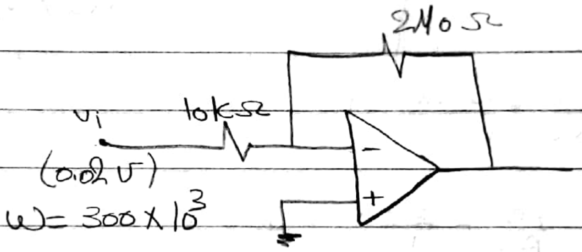
$$v_o = k\sin(2\pi f t)$$

$$\frac{dv_o}{dt} = 2\pi f k\cos(2\pi f t)$$

$$\left.\frac{dv_o}{dt}\right|_{max} = 2\pi f k \leq SR \quad \text{(for no distortion)}$$

$$f \leq \frac{SR}{2\pi k} \qquad \boxed{f_{max} = \frac{SR}{2\pi k}}$$

problem:-




$$V_o = v_{in} * \frac{-R_F}{R_1} = 0.02 * \frac{240}{10} = 0.48V$$

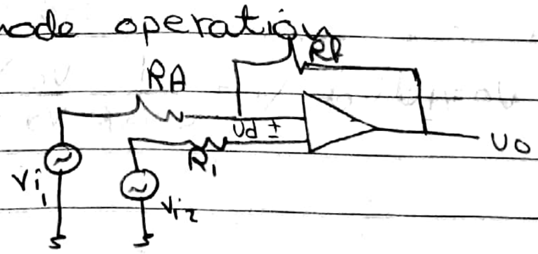
$$f_{max} \leq \frac{SR}{2k\pi}$$

$$w \leq \frac{SR}{k} \qquad = 1.1\times10^6 \text{ rad/s}$$

Differential and common mode operation

Differential inputs

$$V_d = v_{in_1} - v_{in_2}$$



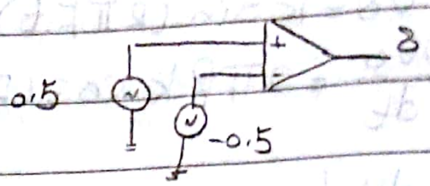

$$V_{od} = A_d\, v_d$$

common inputs

$$v_c = \frac{1}{2}[v_{i_1} + v_{i_2}]$$

output $= A_d v_d + A_c V_C$

## How measure $A_{V_d}, A_{V_c}$ in lab



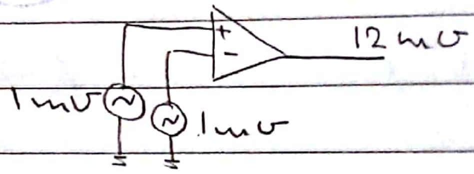

$V_d = 0.5 - (-0.5) = 1\,mV$

$V_C = \frac{1}{2}(0) = 0$

$V_o = A_d V_d + 0$

$A_d = \frac{8}{1\,mV} = 8000$

$dB$ ل $= 20\log\frac{8}{1000}$




$V_d = 0$

$V_C = 1$

$A_C = \frac{V_o}{V_C} = \frac{12\,mV}{1\,mV} = 12$

$CMRR = \frac{A_d}{A_V} = \frac{8000}{12} = 666.7$

$CMRR|_{dB} = 20\log\frac{8000}{12} = 56.48\,dB$

deduce the relation between $V_o$, CMRR

$V_d A_d + V_C A_C = V_o$

$V_o = A_d V_d \left(1 + \frac{V_C A_C}{V_d A_d}\right)$

$V_o = A_d V_d \left(1 + \frac{1}{CMRR}\frac{V_C}{V_d}\right)$

Date Subject

determine output voltage of op-amp, for $v_{i1} = 150 \mu V$

$v_{i2} = 140 \mu V$

$A_d = 4000$

$CMRR = 100$

$v_d = v_{in1} - v_{i2} = 150 - 140 = 10 \mu V$

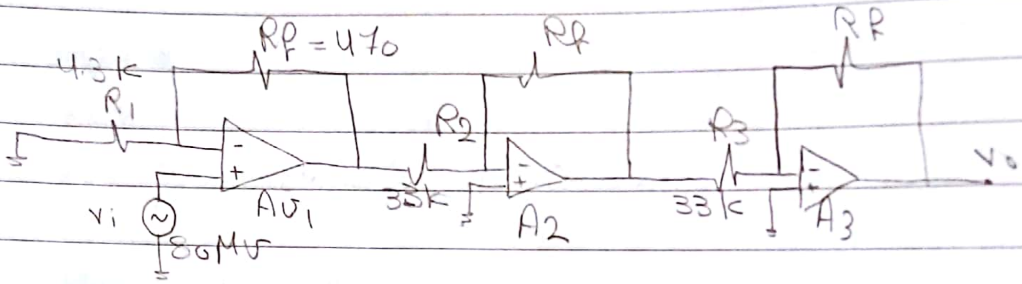
$v_c = \frac{1}{2}[v_{i1} + v_{i2}] = 145 \mu V$

$$v_o = A_d v_d \left[1 + \frac{1}{CMRR} \cdot \frac{v_c}{v_d}\right]$$

Scanned by CamScanner

# op-amp Application

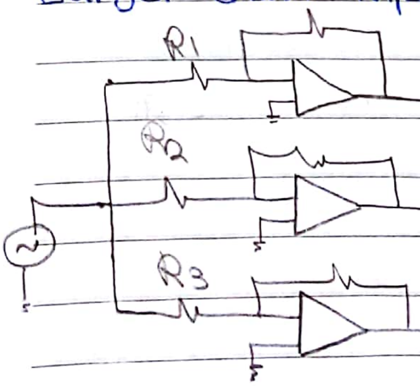
1. Inverting and noninverting Amplifier
2. summation
3. sub
4. integration
5. differentiation
6. multiple stage




$A_V = \frac{V_o}{V_i} = A_1 A_2 A_3$ ratio

$A_V = A_1 + A_2 + A_3$ dB

problem 4:
Show the connection of three op-amps stage LM348 Ic to provide outs that are 10, 20, 50 times Larger than inputs , use Rf = 500k Ω




$V_{o1}$ 10vin $10 = V_{in} * \frac{-500}{R_1}$

$V_{o2}$ 20vin $20 = V_{in} * \frac{-500}{R_2}$

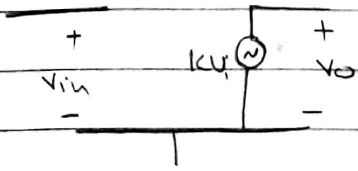
$V_{o2}$ 50vin $50 = V_{in} * \frac{-500}{R_3}$

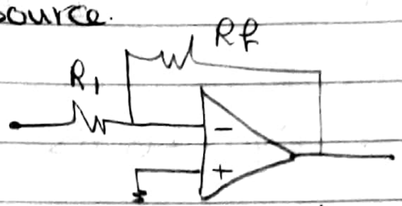
Date Subject

using op-amp as a controlling circuit → voltage
→ current

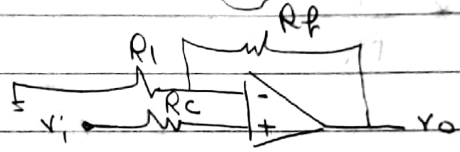
controlled sources

[1] voltage controlled voltage source.



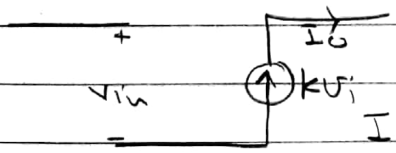




$$v_o = -\frac{R_f}{R_1} v_i \quad \frac{R_f}{R_1} \rightarrow k$$

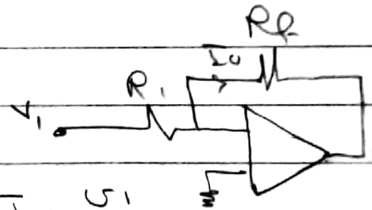



$$v_o = \left(1 + \frac{R_F}{R_1}\right) v_i$$

[2] voltage controlled current source.

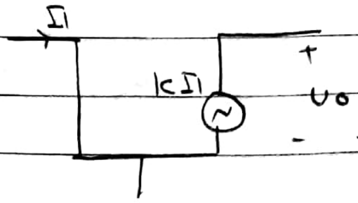



$I_o = k v_i$

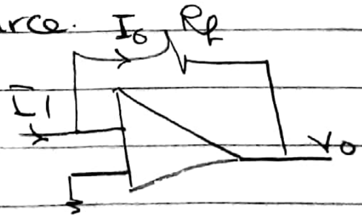



$$I_o = \frac{v_1}{R_1}$$

[3] current controlled voltage source.

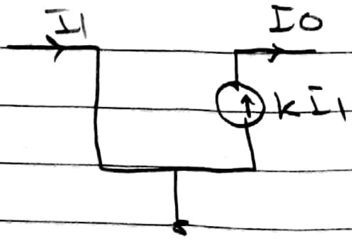



$v_o = k I_1$

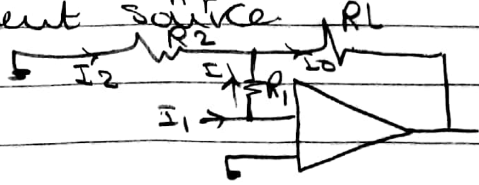



$$\frac{-v_o}{R_f} = I_o \qquad v_o = -I_o R_f$$

[4] current controlled current source.




$I_o = k I_1$



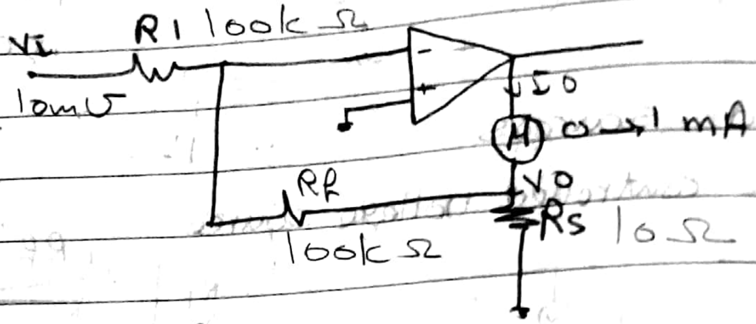

$$I_o = I_1 + I_2$$

$$I_o = I_1 + I_1\left(\frac{R_1}{R_2}\right)$$

$$I_o = I_1\left(1 + \frac{R_1}{R_2}\right) = k I_1$$

Date Subject

Dc millimeter:-



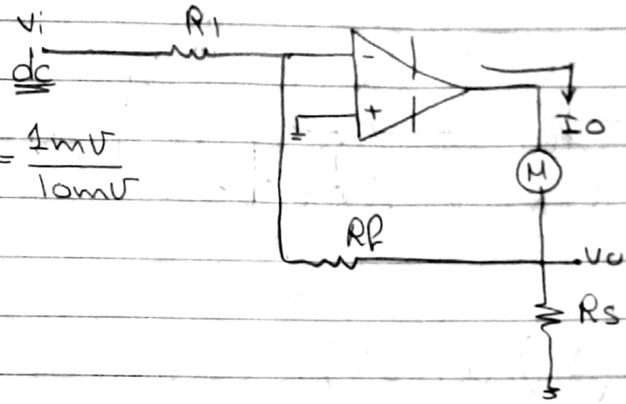

$Vo = Vin * \frac{-Rf}{R_1}$

$Io = \frac{Vo}{Rs}$ $Vo = Io\,Rs$

$Io = \frac{Vin}{RS} * \frac{-Rf}{R_1}$

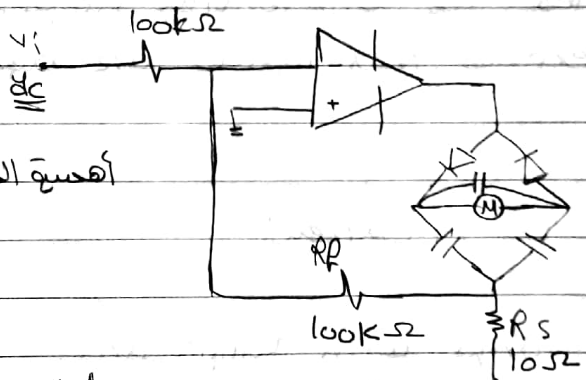
## ① Dc millimeter

Scale small




$$\frac{I_o}{V_o} = \frac{R_f}{R_1}\left(\frac{1}{R_S}\right) = \frac{1mV}{10mV}$$

## ② Ac millimeter

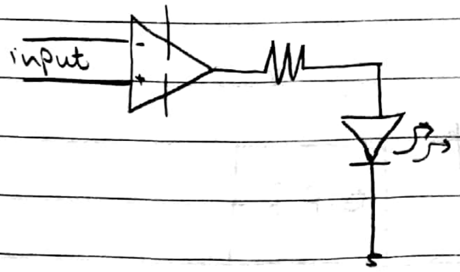


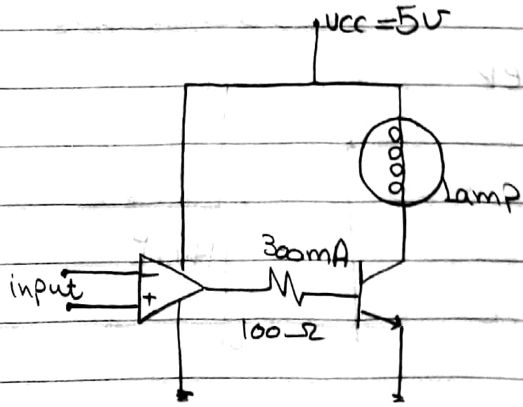

smoothing ← أهمية المكثفات

↳ ripple

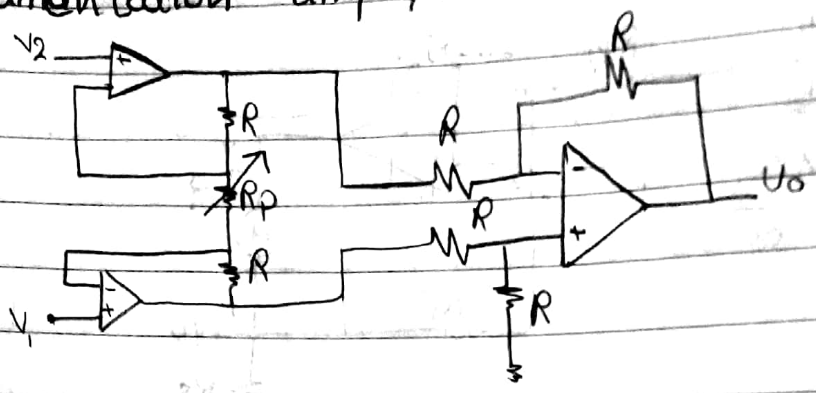
نستخدم هذه الدوائر في لمبة الدايود ويعمل كا Switch لـ Transistor

## ③ Display Dirver



## ④ instrumantation amplifier



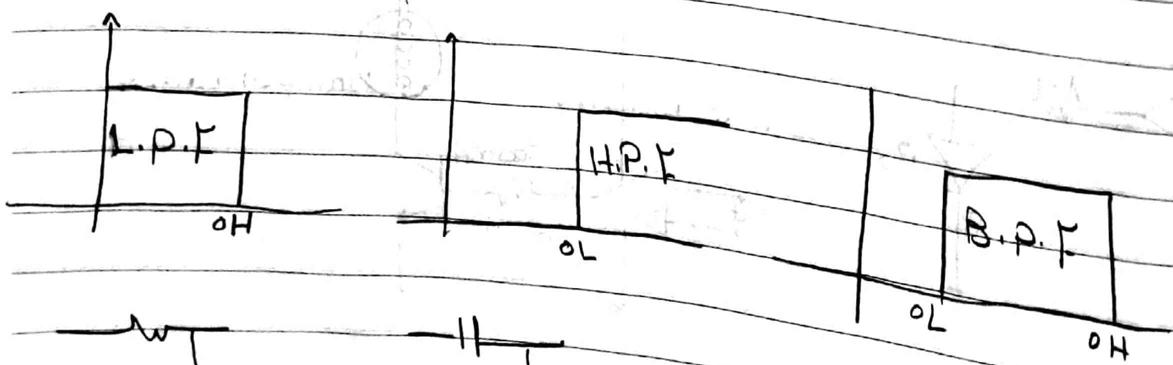

$$V_O = \left(1 + \frac{2R}{R_P}\right)(V_1 - V_2)$$

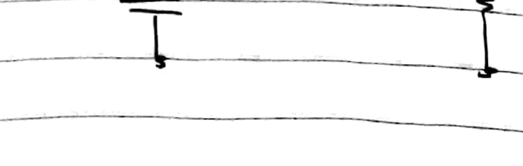
Deduce → [illegible]

→ it resembles the Differential amplifier with the main differance that inputs are buffered by two of dmps

→ Low input bais current
→ High CMRR
→ low offset drift with tempreture.

## Active Filter

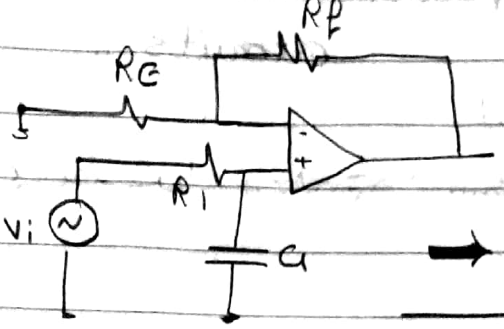


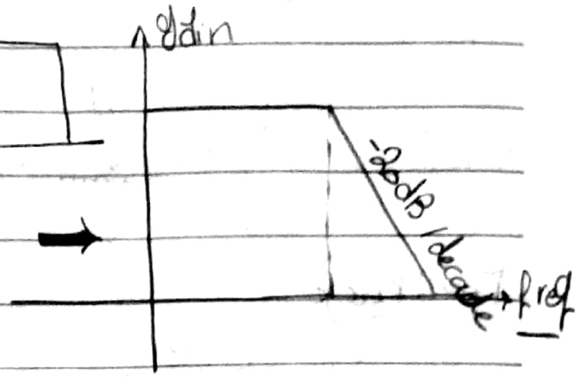



Date Subject

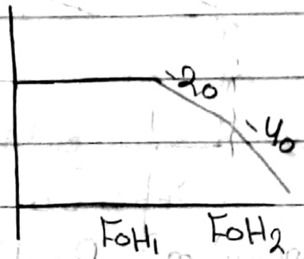
First order L.P.F

$F_{oH} = \frac{1}{2\pi R_1 C_1}$



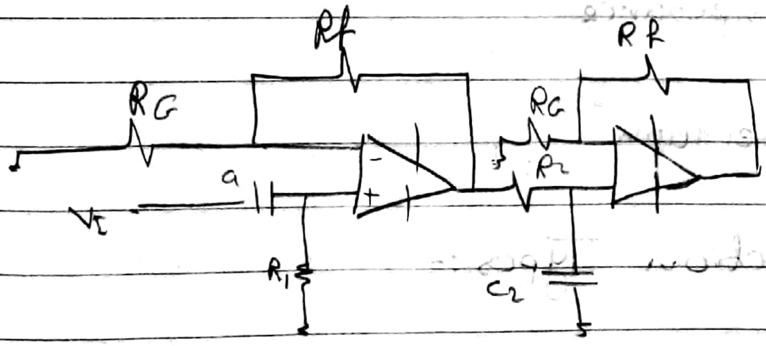




Seconed order → ( 2.First order)




H.P.F ✓

B.P.F

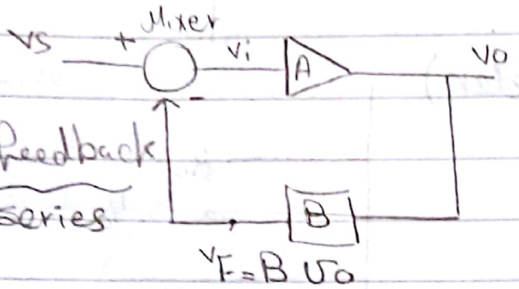



بنعكس ال H.P مع L.P وبنشوف هتفرق ولا لا.

# ch 14 Feedback and oscillator circuits

input مفيش ← oscillator

## Feedback




negative feedback
voltage series

$A_{OL} = \frac{V_o}{V_i}$ without feedback

$A_{cl} = \frac{V_o}{V_s}$ with feed back

### Advantages of feedback

- → Higher input impedance
- → Better stablized voltage gain
- → Improved frequancy responce
- → Lower output impedance
- → Reduce noise
- → more linear operation

### Feedback connection Types:-

1. voltage series Feedback
2. voltage shunt feedback
3. current " "
4. current series "

1- refers to connecting the output voltage as input to the feedback network.

2- current refers to tapping off some output current through the Feedback network.

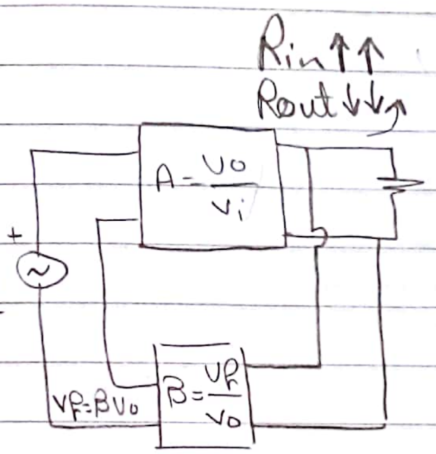
21, 22, 23

Date　　Subject Voltage

→ series refers to connecting the feedback signal in series with the input signal voltage.

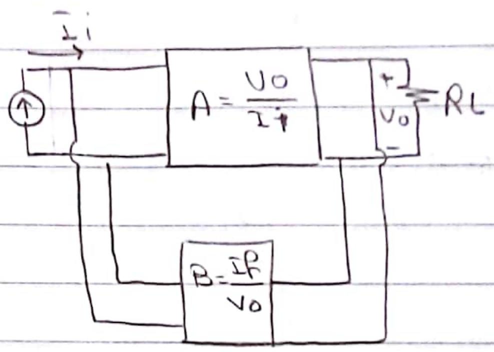
→ shunt refers to conecting the feedback signal in shunt with an input current sorce.

1



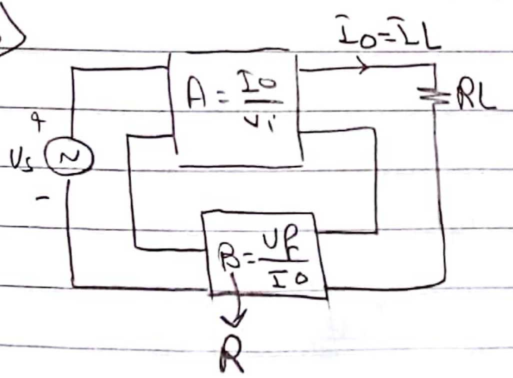

$\beta < 1$

2

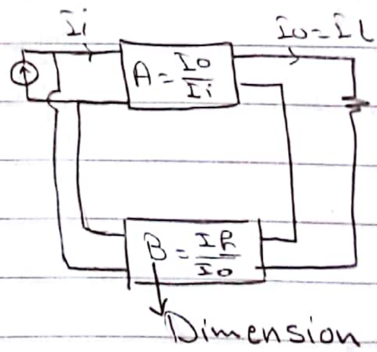



ده احسن نوع

3




4



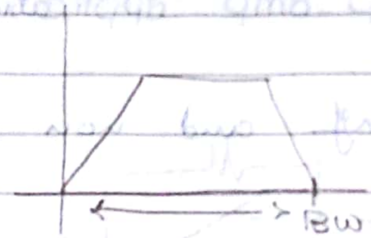

| | voltage series | voltage shunt | current series | current shunt |
|---|---|---|---|---|
| gain A without | $\frac{V_o}{V_i}$ | $\frac{V_o}{V_i}$ | $\frac{I_o}{V_i}$ | $\frac{I_o}{I_i}$ |
| $\beta$ | $\frac{V_f}{V_o}$ $\beta V_o$ | $\frac{I_f}{V_o}$ | $\frac{V_f}{I_o}$ | $\frac{I_f}{I_o}$ |
| gain Af with | $\frac{V_o}{V_s}$ | $\frac{V_o}{I_s}$ | $\frac{I_o}{V_s}$ | $\frac{I_o}{I_s}$ |

$\boxed{18}$ $F_c = ??$

$B_1 = 800k\Omega$

$A_{vd} = 150\ v/mv$

$$\underset{\Downarrow = F_c}{G_{din} \times BW} = const\ (B)$$




$\boxed{19}$ $SR = 2.4\ v/\mu s$

$$A_{cL} = \frac{SR}{\Delta v_i/\Delta t} = \frac{2.4 \times 10^{-6}}{0.3/10 \times 10^{-6}}$$

$\boxed{21}$

$$V_{offset} = V_{offset_{V_0}} + V_{offset_{I_0}}$$

$$= \left[1 + \frac{R_f}{R_i}\right] V_{I_0} + I_{I_0} R_f$$

$\boxed{22}$

$$A_{cL} = \frac{-R_f}{R_1}$$

$Z_i = R_1$

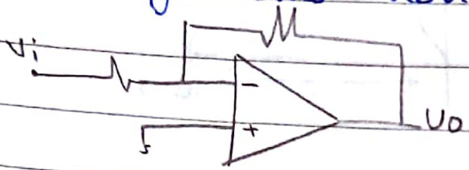
$Z_o = R_o / 1 + A\beta$

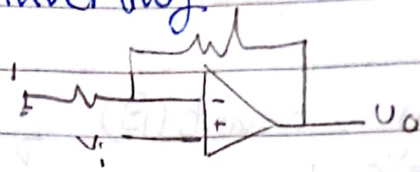
-ve Feedback Amplifier

Date sec Subject

# CH4:- op-amp application:-

## [1] inverting and non inverting




$A_V = \dfrac{-R_f}{R_i}$ $\qquad$ $A_V = \left(1 + \dfrac{R_f}{R_i}\right)$

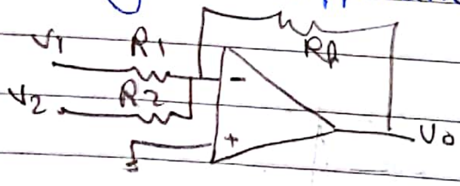
## (2) Buffer

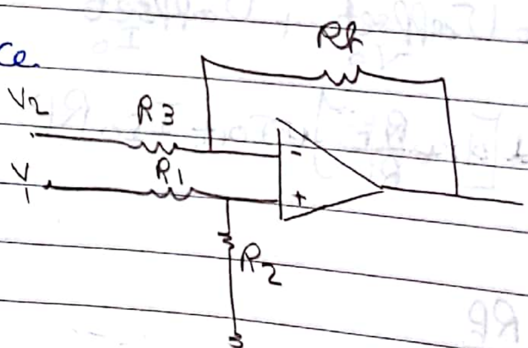
$R_f = S.C \quad 0$

$R_i = O.C \quad \infty$

$A_V = 1$

## [3] summing , differance



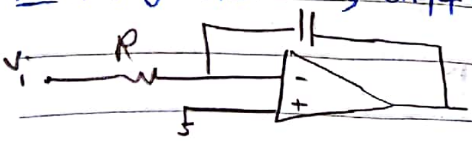



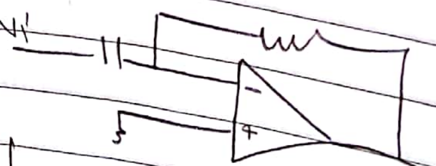

$$V_o = -\left[\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2\right]$$

$$V_o = V^+ \left[1 + \frac{R_f}{R_3}\right] - V^- \frac{-R_f}{R_3}$$

$V^+ = V_1 * \dfrac{R_2}{R_1 + R_2}$ $\qquad$ $V^- = V_2$

## [4] integrator , differentiator




$V_o = \int v_i(t)\, dt + V_o * \dfrac{-1}{RC}$

الشحنة الابتدائية

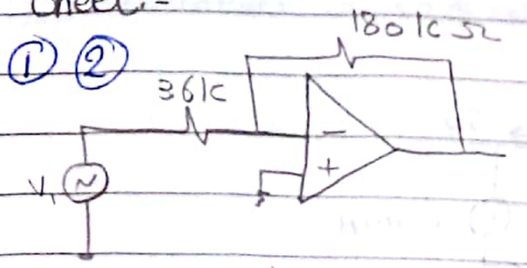
$V_o = \dfrac{dV_i}{dt} * -RC$

4 Writ

Date Subject

sheet:-

① ②




inverting و non inverting

## [5] multiple stage amplifier

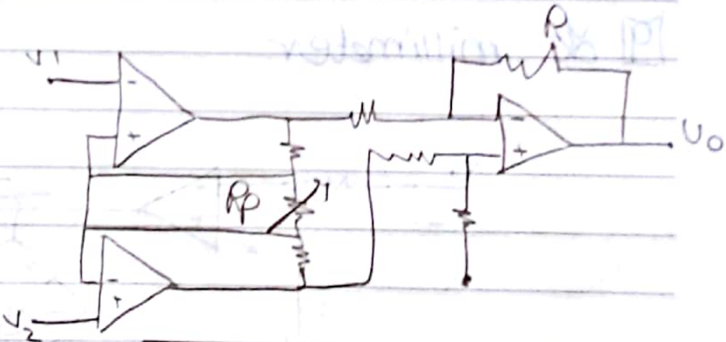
استخدام كذا amplifier

① → ② → ③ →

$A_v = A_1 A_2 A_3$

## [6] instrumentation amplifier

يتم استخدام الدائرة للتحكم في $V_1$ و $V_2$
ويتم التحكم في scale عن طريق
المقاومة المتغيرة $R_P$




$$\frac{V_o}{V_1 - V_2} = \left[1 + \frac{2R}{R_P}\right]$$

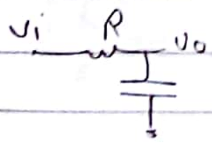
$\boxed{R_F = 2R}$

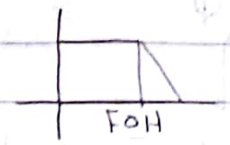
## [7] active Filters

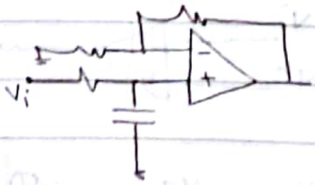
Passive: | R-L-C |

active: | op-amp - BJT |

L.P.F

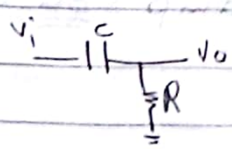


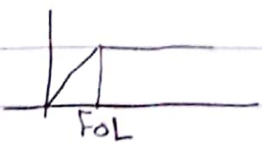




L.P.F

H.P.F



Date Subject

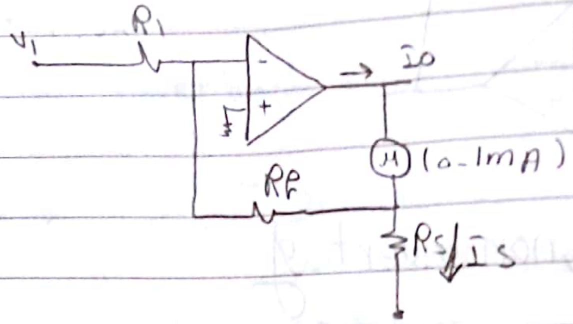
scale

## [8] Dc millivoltmeter

لو الـ op-amp مثالي

① $R_{in}\uparrow\uparrow$ $R_o\downarrow\downarrow$

② اختيار المقاومات بدقة




$$V_o = \frac{-R_f}{R_1} V_1$$

$\downarrow$

$I_s R_s$

$\downarrow$

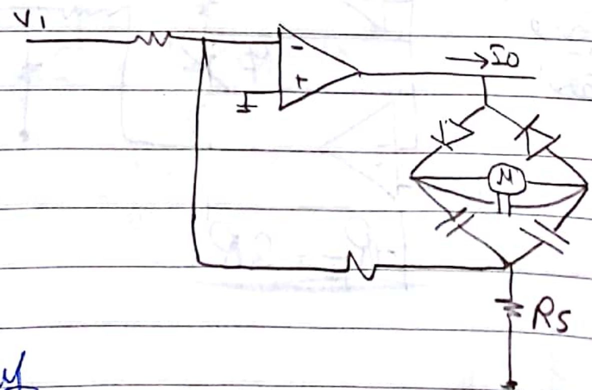
$$+I_o R_s = \frac{+R_f}{R_i} V_1$$

← علشان مكبر مابين $V_1$ و $I_o$

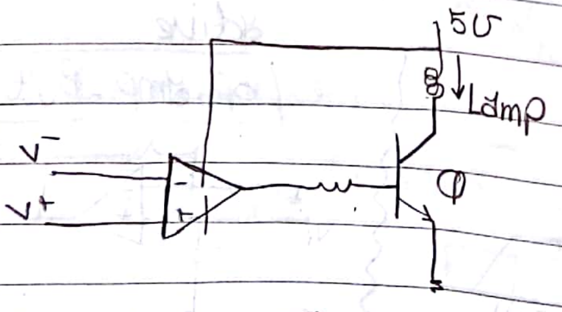
$$\frac{I_o}{V_1} = \frac{R_f}{R_i R_s}$$

## [9] ac millimeter

استخدام $V_{rms}$




## display [10] Driver




$V^+ > V^-$ $V_o$ +ve Q on $\rightarrow I_c$ lamp on

$$1+\frac{R_f}{R_3}=\frac{R_f}{R_3}$$

$$\frac{1+R_f}{R_3}=\frac{R_f}{R_3}$$

$1+R_f$ $\Leftarrow V_o = V^+ - V^-$

Date Subject

[11] Controlled dependant source

حسب الدخل بيتحكم خارجه لزع

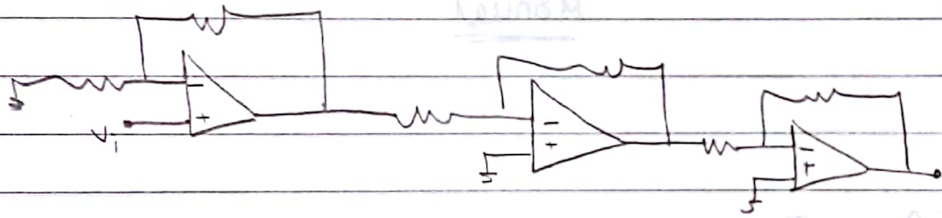
$$I_o = I_1 = \frac{V_1}{R_1} = \boxed{\frac{1}{R_1}}_{\text{c/s}} V_1$$ $\Leftarrow$ voltage control current source.

[3] Sheet

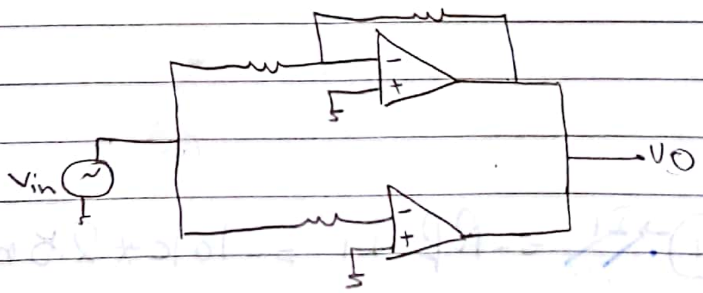
$A_V = A_1 A_2 A_3$

$V_o = A_{VT} \cdot V_o$

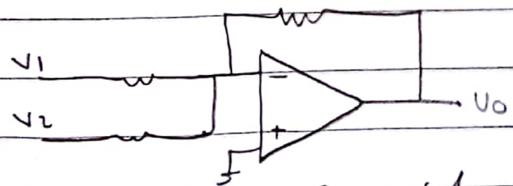
[4]




[5]




[6]




$V_1 = V_2$

$$V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2\right]$$

[7] $$V_o = V^+\left(1+\frac{R_f}{R_3}\right) - V^-\left(\frac{-R_f}{R_3}\right)$$

$V^+ = V_1 * \frac{R_1}{R_1+R_2}$, $V^- = 2$

4 Write